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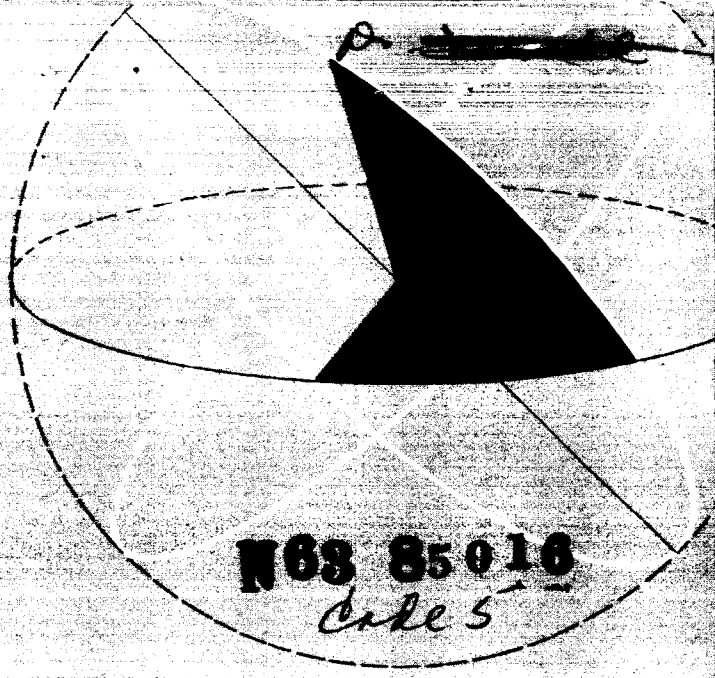

LITERATURE SEARCH NO. 183

PLASMA PHYSICS AND MAGNETO-FLUID-DYNAMICS

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PLASMA PHYSICS AND MAGNETO-FLUID-DYNAMICS

Rowena Rodabaugh

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FOREWORD

Because of the widespread interest in plasma physics and magneto-fluid-dynamics, it was felt that an annotated bibliography on this subject would be helpful. The field has grown and is growing so rapidly that an arbitrary cut-off date was used, and the majority of references fall only within 1959, 1958, and 1957. The references given in the recent articles will enable the researcher to trace preceding works of special interest.

The sources where the references and abstracts were found are noted beneath the citations. The following source abbreviations are used: *Physics Abstracts* (*PA*); *Applied Mechanics Reviews* (*AMR*); *Nuclear Science Abstracts* (*NSA*); *Aero/Space Engineering* (*A/SE*); *American Rocket Society Journal* (*ARS Journal*); *Pacific Aeronautical Library* (*PAL*).

For additional information on magnetohydrodynamics in relation to propulsion systems, see also JPL Astronautics Information Search No. 207, entitled "Methods of Advanced Propulsion."

The author wishes to acknowledge the assistance of Dr. Fumio Yagi of the Jet Propulsion Laboratory.

PREFACE

The technical staff of the Jet Propulsion Laboratory library is engaged in an extensive literature searching program covering subjects selected by the Laboratory engineers and designed to meet their individual needs. Searches considered to be of interest to persons working in the field of astronautics will be published for distribution to interested organizations.

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6. **UNDIMENSIONAL MOTION IN MAGNETO-HYDRODYNAMICS**
Golitsyn, G. S.
***Zhurnal Eksperimentalnoi i Fiziki*, SSSR, pp. 776–781, September 1958 (Translated in *Soviet Physics–JETP*, pp. 538–541 , March 1959)**

Investigation of the motion of a perfectly conducting gas in a magnetic field. The Riemann invariants for a number of gases are computed and some nonstationary problems are solved. A new method is proposed for obtaining an approximate general solution of the magnetohydrodynamic equations. A number of problems in which the presence of shock discontinuity plays an essential role are considered in detail. (*A/SE*, May 1959)

7. **TOCHNYE RESHENIIA URAVNENII DVIZHENII MAGNIINOI GIDRODINAMIKI PREDELNYKH K AUTOMODELNYM**
Kochina, N. N.
***Akademii Nauk SSSR, Doklady*, pp. 528–531, May 21, 1959 (in Russian)**

Derivation of exact solutions for the equations of magnetohydrodynamics, considering the case of one-dimensional nonsteady motion of an ideal conducting gas is given. The approach developed previously for the case without magnetic forces is generalized, and the results are presented for the problem of cylindrical symmetry. (*A/SE*, October 1959)

8. **TWO-DIMENSIONAL HYDRODYNAMIC CALCULATIONS**
Harlow, F. H., et al.
University of California, Berkeley
LASL Report LA-2301, September 1959
(97 pp., 14 ref.)

Extension of a previously developed method for solving two-dimensional hydrodynamic problems. The calculation procedure is described in detail and illustrated on problems involving cartesian coordinates in a rigid rectangular box, other boundary conditions in cartesian coordinates, generalized problems in cartesian coordinates, and two-dimensional calculations in cylindrical coordinates. The limitations of the method are evaluated. Covered are such aspects as the shock-wave refraction with corner effects, shock passage through a discontinuously enlarged channel, interaction of a shock with perturbed interface, Taylor instability, and viscous flow calculations. (*A/SE*, January 1960)

9. **TRANSPORT PHENOMENA IN A COMPLETELY IONIZED TWO-TEMPERATURE PLASMA. APPENDIX—CALCULATION OF MATRIX ELEMENTS**
Braginskii, S. I.
***Zhurnal Eksperimentalnoi i Fiziki*, SSSR, pp. 459–472, August 1957 (Translated in *Soviet Physics–JETP*, pp. 358–369, February 1959)**

(Abstracted in *Aero/Space Engineering*, July 1958)

10. **VACUUM ELECTRODYNAMICS ON A MERRY-GO-ROUND**
Ise, J. and Uretsky, J. L.
***American Journal of Physics*, v. 26, no. 7, pp. 431–435, October 1958**

Maxwell's equations in a relativistic, rotating reference frame are discussed by use of a covariant formalism. (*PA*, 1959, #461)

11. **VARIATIONAL APPROACH TO MAGNETO-FLUID-DYNAMICS**
Rosen, P.
***Physics of Fluids*, v. 1, no. 3, p. 251, May–June 1958**

As previously shown (*Journal Chemical Physics*, v. 21, p. 1220, 1953), the Rayleigh-Onsager principle of least dissipation of energy (*Physical Review*, v. 37, p. 405, 1931) can be used to obtain a variational principle for the flow of a viscous incompressible fluid. Adding joule losses to the viscous dissipation and suitably modifying the energy balance statement, he now arrives at a more general variational principle applying to the motion of a viscous adiabatic fluid with finite electrical conductivity. Displacement currents are omitted, as is consistent with the non-relativistic character of the analysis. (*AMR*, 1959 #1031)

12. **TRACING BACK THE KINETIC EQUATION TO THE DIFFERENTIAL FORM IN THE CASE OF COULOMB COLLISIONS**
Trubnikov, B. A.
***Zhurnal Eksperimentalnoi i Fiziki*, SSSR, v. 34, no. 5, pp. 1341–1343, 1958 (in Russian) (English summary PB 141052T-2 obtainable from Office of Technical Services, U. S. Department of Commerce, Washington, D. C.)**

By introducing "potential functions" as new unknowns in the expression for the flow of a completely ionized plasma, the integro-differential equations can be reduced to pure differential equations, the order of which can be reduced in special cases. For a "moving" Maxwell distribution all equations can be linearized. (*PA*, 1959, #9730)

13. TRAJECTORY-WISE-ANALYSIS OF CYLINDRICAL AND PLANE PLASMAS IN A MAGNETIC FIELD AND WITHOUT COLLISIONS

Tonks, L.

***The Physical Review*, v. 113, no. 2, pp. 400–407, January 15, 1959**

The anatomy of the transition region between vacuum and a fully developed magnetically immobilized ionized-gas plasma has been examined by following particle trajectories in detail. The mathematical formulation required machine computation for its full interpretation. This approach recognizes the structure imparted to the plasma by the radius of gyration and thus serves as a critique of the magnetohydrodynamic method. It furnishes the microscopic verification of that macroscopic approach and supplements it by showing that the sharpness of transitions in a plasma are limited, in effect, by the gyration radius in the stronger, not the weaker, magnetic field. Especially, it brings out the greater importance of the tensor character of the plasma pressure in the cylindrical case where the combined kinetic and magnetic energy density in uniform interior regions of the plasma is not equal to the magnetic energy density in the vacuum. The analysis also exhibits the intense mass motion at the surface of a strong plasma constituting a paramagnetic electric current and probably having dynamical effects. The numerical work is correlated where possible with direct theoretical results. (*PA*, 1959, #4742)

14. ZEMPLEN'S THEOREM IN MAGNETOHYDRODYNAMICS

Iordanskii, S. V.

***Akademii Nauk SSSR, Doklady*, v. 121, no. 4, pp. 610–612, 1958 (in Russian)**

The theorem states a general relationship between the normal and tangential components of the magnetic field, the current density, and the fluid density and pressure at two points in the continuum. After an outline of the general proof, this theorem is particularized to the case of vorticity by allowing the two specified points to approach indefinitely close to each other, while remaining on opposite sides of a pressure discontinuity. (*PA*, 1959, #4836)

15. TORUSLIKE CONFIGURATIONS OF A PLASMA IN EQUILIBRIUM WITH AN EXTERIOR MAGNETIC FIELD WITHOUT AZIMUTHAL CURRENT

Meyer, F., and Schmidt, H. U.

***Zeitschrift für Naturforschung*, v. 13a, no. 12, pp. 1005–1015, December 1958**

The authors attack the problem of the existence of toruslike configurations of a plasma in an equilibrium with an exterior magnetic field. The starting point is the Maxwell equations with the pressure of the gaseous medium being constant over the entire external surface of the forus. The first problem is to solve the following question: Do toruslike surfaces exist with meridional, closed and equally distributed current lines? To answer this, consideration is given to the geometry of the toruslike surface and then to establishing a differential equation based on the equation of the length of an arc. The first answer is that there cannot exist a torus configuration with plane, closed current lines, whose planes pass through the z-axis. To find the possible configurations, they solve the equation in question by means of characteristics which are identical with the lines of the magnetic field. The current lines can be closed plane curves but their planes cannot pass through one and the same axis. The disturbances in the distribution of the initial values propagate always along characteristics. The plasma cross section must have maxima and minima. Authors construct a few possible toruslike configurations, show their azimuthal and meridional cross sections and prove that they always must possess an azimuthal component of the current. Finally they constructed a paper model of a torus, whose picture shows many interesting details. This is a nice contribution to the field in question. (*AMR*, 1959, #6333)

16. THE THERMAL CONDUCTIVITY OF A PLASMA

Schirmer, H., and Friedrich, J.

***Zeitschrift für Physik*, v. 153, no. 5, pp. 563–570, 1959 (in German)**

A theoretical paper dealing with the development of the Boltzmann equation in a study of "heat loss" components from discharges. Principal factors are electron transport, thermal diffusion, etc. (*PA*, 1959, #8254)

17. THE SLOW MOTION OF A PERMANENTLY MAGNETIZED SPHERE IN AN ELECTRICALLY CONDUCTING MEDIUM

Barthel, J. R., and Lykoudis, P. S.
Purdue University, School of Aeronautical Engineering, Lafayette, Ind.
Research Project No. 1717, Project AE-33, Report No. A-59-11, August 1959

18. THERMODYNAMIC FOUNDATION OF THE THEORY OF PLASMA

Kihara, T.
***Journal of the Physical Society of Japan*, v. 14, no. 2, pp. 128–133, February 1959**

The thermodynamics of irreversible processes is applied to dense plasmas in a weak magnetic field. The basic equations of "magneto-thermo-hydrodynamics" are derived, together with the various relations between transport coefficients. Extremely dilute plasmas and plasmas at the Debye-Hückel limit are discussed as particular cases. (*PA*, 1959, #9727)

19. THE PROPAGATION OF SMALL DISTURBANCES IN HYDROMAGNETICS

Ludford, G. S. S.
***Journal of Fluid Mechanics*, v. 5, no. 3, pp. 387–400, April 1959**

Paper deals with the propagation of small initial disturbances in a conducting gas under the influence of a uniform external magnetic field. The starting point is the usual system of equations of magneto-gasdynamics, with the coefficients μ (permeability) ε (dielectric constant) and σ (conductivity) being constant and the charge density different from zero. Introducing a deviation from a given uniform state and neglecting squares, author obtains a system of nine first-order linear partial differential equations. The first problem solved is that of plane waves, with the initial set splitting into two sets, leading to a quartic and quintic for the frequency. From the roots, three give pure decay, and the remaining six three possible modes of propagation of sinusoidal disturbances (one is an Alfvén wave). The next item shows that the general linearized equations can be split into two sets of four and five, which lead to partial differential equations of the order two and four, respectively.

The boundary-value problem of standing waves in the fluid confined in a rectangular box made of a perfectly conducting material is discussed next. Three types of waves appear: those corresponding to an infinity of frequencies associated with the Alfvén velocity, and two others distinguished by their symmetry properties. The distributions of frequencies are sketched for the two extreme cases of very weak and very strong external fields. The limiting forms of the waves for the two extreme cases are also considered; a discussion of the general initial-value problem and of the determination of Fourier coefficients referring to the standing waves closes the paper. (*AMR*, 1959, #6326)

20. THEORY OF ELECTROMAGNETIC RESEARCH: DIFFRACTION IN INHOMOGENEOUS MEDIA

Seckler, B. D., and Keller, J. B.
Institute of Mathematical Sciences, New York University, Electromagnetic Research Division
Research Report MME-7, November 1957
DA-49-170-SC-2253

A geometric method is given for finding the field in inhomogeneous media containing smooth convex bodies. The field due to a plane wave in an unbounded medium is constructed by introducing complex rays in the refraction shadow. The occurrence of diffracted rays in the boundary problems is explained, and the field along the rays obtained. General formulae are obtained for diffraction coefficients. The theory is then applied to several problems with the medium plane, or cylindrically stratified, and the boundary planar, or circular. Expressions for the exact solution to such boundary-value problems are determined and asymptotic forms are obtained.

21. THEORETICAL STUDY OF THE ELECTRON DISTRIBUTION IN A HETEROGENEOUS AND ANISOTROPIC LORENTZIAN PLASMA

Jancel, R., and Kahan, T.
***Journal de physique et le Radium*, v. 20, no. 1, pp. 35–42, January 1959 (in French)**

A general expansion in spherical harmonics for the electron distribution function is used to obtain a solution of the transport equation for a weakly ionized inhomogeneous (existence of density gradient) and anisotropic plasma (in the presence of electric and magnetic fields). This solution gives rise to a system of differential equations, and the solution of this system of equations gives the first two approximations to the distribution function. (*PA*, 1959, #3594)

22. THEORETICAL STRUCTURE OF PLASMA EQUATIONS
Rosenbluth,M. N., and Rostoker, N.
***Physics of Fluids*, v. 2, no. 1, pp. 23–30, January–February, 1959**

In high-temperature plasmas, collisions are very infrequent. Thus, the charged particles travel on independent orbits determined by the electromagnetic field. At first sight this would seem completely different from a conventional fluid where particles are closely hemmed in by their neighbors. However, there can exist collective modes of motion in which the particles interact with each other by altering the fields. In this paper a new method is developed for the solution of the linearized transport equation and by facilitating direct use of the properties of particle orbits, a considerable simplification is achieved. In particular, a variational expression is derived for determining stability which is rigorous in the limits of small Larmor radius. (*PA*, 1959, #3599)

23. THEORETICAL RESEARCHES IN MAGNETO-HYDRODYNAMICS
Holter, Ø. et al.
The Institute of Theoretical Astrophysics, Oslow University, Norway
Final Technical Report under Contract No. AF 61 (052)-49, June 30, 1959

24. THE MATERIAL EQUATIONS IN ARBITRARY MEDIA
Tinchar, M. and Hess, S.
***Annalen der Physik*, Leipzig, Folge 7, v. 3, no. 3–4, pp. 113–121, 1959 (in German)**

Following the generalization of the two equations introducing the dielectric constant and the permeability by Marx (*PA*, 1954, #6737) and by Schmutzen (*PA*, 1957, #3459) a covariant formulation including Ohm's Law is given. This leads to a new equation for the magnetic part of the current arising from the motion of the medium. Apart from the factor $(1 - v^2/c^2)^{1/2}$, the current tensor is the same as that defined by Schlomka (*PA*, 1951, #6357). (*PA*, 1959, #12505)

25. THE MAXIMUM DISTURBANCE GROWTH RATE FOR AN UNSTABLE PLASMA COLUMN
Kaneko, S.
***Journal of the Physical Society of Japan*, pp. 947–953, August 1958**

(Abstracted in *Aero/Space Engineering*, November 1958)

26. THE INSTABILITIES OF A CYLINDRICAL GAS DISCHARGE WITH FIELD PENETRATION
Hubbard, J.
Atomic Energy Research Establishment, Harwell Report T/R 2668, 1958 (17 pp.)

This report describes a calculation of the stability with field penetration, in which the effects of finite conductivity and viscosity are approximately taken into account. A wide range of field configuration was investigated. (*PA*, 1959, #3593)

27. THE EQUILIBRIUM OF A SELF-GRAVITATING INCOMPRESSIBLE FLUID SPHERE WITH A MAGNETIC FIELD. II.
Prendergast, K. H.
***Astrophysical Journal*, p. 361, July–November 1958**

28. THE EFFECT OF THE SELF-MAGNETIC FIELD UPON THE CHARACTERISTICS OF A POSITIVE COLUMN WITH AXIAL SYMMETRY
Hoyaux, M. and Gans, P.
Working Group of Electrical Construction in Charleroi (Ateliers de Constructions Electriques de Charleroi)
AF 61(514)-630-C, ARDC-TN-54-1
(ASTIA AD-66,705)

The motion of the charge carriers in the positive column of a discharge in a gas is investigated, taking into account the forces due to the self-magnetic field of the arc. An integral equation for the redial distribution of the ionization density is set up and solved numerically. The solution depends upon a parameter A which is introduced into the theory and which is essentially a measure of the effect of the magnetic field. The equation has been solved for various values of this parameter and suitable methods of interpolation developed.

29. THE CIRCUIT DYNAMICS OF PLASMA
Liley, B. S.
***Institution of Electrical Engineers, Proceedings of the*, Paper 2899 (Convention on Thermonuclear**

Processes) published April 1959 (8 pp.) (To be republished in Vol. 106A, 1959)

Equations applicable to the behavior of plasma in bulk are derived and discussed. Starting with the equations of plasma dynamics the total and thermal energy equations are integrated over all space. Certain bulk variables such as the geometrical dimensions of a conductor and the total charge in a circuit are then introduced. Subsequent definition of various circuit parameters and the introduction of generalized e.m.f.'s permit the integrated equations to be expressed in terms of the bulk variables. Using the fact that the total energy is constant, it is possible to obtain the equations of circuit dynamics, applicable to a plasma in Lagrangian form. The derivation is not vigorous, relying for its validity on physical arguments and the consistency of the final equations with those of plasma dynamics. Again, the proof is confined to cases in which the nature of the functions determining the distribution of mass, current and charge density throughout the volume of a conductor are time-independent. The generalized e.m.f. concept is unfamiliar, it mainly arises from coupling between the electrical and thermal properties of a plasma. It is shown that these e.m.f.'s lead to a form of magneto-resistive coupling and, even in the absence of Hall currents, an apparent anisotropic resistivity. A general proof of the equivalent transformer circuit is given. (*PA*, 1959, #4737)

30. THE ANALOGUE OF KELVIN'S THEOREM IN HYDROMAGNETICS

De, J.

***Naturwissenschaften*, v. 44, no. 8, p. 256, 1957**

Consideration of the hydromagnetic field equations of an infinitely conducting, incompressible, inviscid fluid shows that the magnetic lines are frozen in the fluid, i.e., they move with the fluid in the same sense as vortex lines do in the hydrodynamic field under the action of conservative forces. It is shown that it follows from this that the circulation $\int$ vs. ds along a closed magnetic line is a constant of the motion. (*PA*, 1959, #471)

31. TEIRIIA MAGNITNOGO POGRANICHNOGO SLOIA

Zhigulev, V. N.

***Akademii Nauk SSSR, Doklady*, pp. 1001–1004, February 11, 1959 (in Russian)**

This report discusses the development of the theory of magnetic boundary layers and presents examples illustrating the phenomenon occurring in moving plasma. The case of a semi-infinite plate in a conducting fluid at rest is studied for varying directions of the electric current. The pressure across the magnetic boundary layer is calculated and it is shown that the moving plasma tends to separate from the outer magnetic field and the electric currents passing through it. In the case of motion at high magnetic Reynolds numbers, the thickness of the layer is of the order of $1/\sqrt{Re_m}$. (*A/SE*, August 1959)

32. TABLES TO CALCULATE THE ELECTROMAGNETIC FIELD IN THE SHADOW REGION FOR VARIOUS SOILS

Bekina, M. G.
Friedman, M. D., Translator
(ASTIA AD-110, 298)

Working from the expression previously obtained by V. A. Fok for the Hertz function of a vertical dipole situated above the surface of a homogeneous spherical Earth, the problem and basic formulas are explained, the parameters defined, and group velocity values obtained. The method of calculation is explained and an example given. The rest of the report is devoted to tables and graphs.

33. SUPERFICI DI DISCONTINUITA IN MAGNEFLUIDODINAMICA

Napolitano, L. G.

***L'Aerotecnia*, pp. 210–220, August 1958 (in Italian)**

Derivation of the basic equations for discontinuities in magnetofluiddynamics, and a discussion of their solutions in relation to contact and vortical discontinuities is given. The electric conductivity is considered to be infinite, constant, and variable with the absolute temperature. It is found that contact discontinuities are always possible in the first two cases, whereas, vortical discontinuity surfaces are possible only when the magnetic field has no component normal to the surface itself ($Hn = 0$). For $\sigma = \sigma\ (T)$ vortical discontinuity surfaces are always possible, and their characteristics, when $Hn = 0$, depend upon the surface geometry and the tangential component of the electric field. The existence of contact surfaces implies the existence of discontinuitis in the magnetic field unless the tangential component of the electric field vanishes. (*A/SE*, February 1959)

34. NOTES ON MAGNETO-HYDRODYNAMICS, NO. I: GENERAL FLUID EQUATIONS
Grad, H.
New York University, Institute of Mathematical Sciences, August 1, 1956
Atomic Energy Commission Computing Facility, NYO-6486 No. I
AT(30-1)-1480

35. NOTES ON MAGNETO-HYDRODYNAMICS, NO. III: SPECIAL SOLUTIONS
Grad, H.
New York University, Institute of Mathematical Sciences, August 14, 1956
Atomic Energy Commission Computing Facility, NYO-6486, No. III
AT(30-1)-1480

36. NOTES ON MAGNETO-HYDRODYNAMICS, NO. IV: OHM'S LAW
Grad, H.
New York University, Institute of Mathematical Sciences, August 20, 1956
Atomic Energy Commission Computing Facility, NYO-6486, No. IV
AT(30-1)-1480

37. MICROSCOPIC ANALYSIS OF MAGNETO-GAS-DYNAMICS
Covert, E.
Massachusetts Institute of Technology, Naval Supersonic Laboratory, Cambridge, August 24–29, 1959
TR-395

The kinetic theory approach to magneto-gas-dynamics is discussed. The several methods of considering interactions, in which the long range forces are of importance, are compared critically. In particular, the effects of the magnetic field on the particle interactions and their trajectories are shown to introduce anisotropies in magneto-gas-dynamics. The effects of these anisotropies are briefly discussed.

38. MAGNITNAI GIDRODINAMIKA
Elzasser, V. M.
***Uspekhi Fizicheskikh Nauk*, SSSR, pp. 529–588, March 1958 (In Russian) (146 ref.)**

This is a study of magnetohydrodynamics covering the basic magnetic concepts, magnetohydrodynamic waves, turbulence and instability, formation of cosmic magnetic fields, secular variations of the Earth's magnetic field, paleomagnetism, solar and astral magnetism, and fields in the rarified cosmic gas. (*A/SE*, July 1958)

39. IRREVERSIBLE STOCHASTIC THERMODYNAMICS AND THE TRANSPORT PHENOMENA IN A REACTING PLASMA
Kaeppeler, H. J. and Baumann, G.
***Forschungsinstitut für Physik der Strahlantriebe E. V. Mitteilungen*, Vol. 8, November 1956 (104 pp.)**
(*Jet Propulsion*, Technical Literature Digest 1958)

40. MAGNETOHYDRODYNAMICS AND MAGNETOGAS DYNAMICS
Pai, S. I.
University of Maryland, Institute on Fluid Mechanics and Applied Mathematics, College Park
AF 18(600)-993, AFOSR-TN-55-347
TN-BN-59, September 1955
(ASTIA AD-74432)

The fundamental equations of magneto fluid dynamics are derived. For incompressible fluid, magnetohydrodynamics, the important parameters are the Reynolds number, the magnetic pressure number, which is the ratio of magnetic pressure to dynamic pressure, and the velocity number, which is the ratio of the fluid velocity to the characteristic velocity of which the magnetic field is moving through a conductor. Some exact solutions and properties of the equations of magnetohydrodynamics are given. Stability of laminar flow and turbulence in magnetohydrodynamics are briefly reviewed. Finally, some magnetohydrodynamic experiments are described.

41. MAGNETOHYDRODYNAMIC DISTURBANCES DUE TO THE SUDDEN INTRODUCTION OF A MAGNETIC DIPOLE IN A FLUID OF FINITE CONDUCTIVITY
el Mohandis, G. S.
***Astrophysical Journal*, v. 129, no. 1, pp. 172–193, January 1959**

Mathematical solutions for the magnetohydrodynamic perturbations are given for the case of a magnetic dipole placed either parallel or perpendicular to the exciting field in an infinite fluid of finite electrical conductivity. Walen's (1944) approximation is used, and charts representing the excited field, the total field, and fluid motion are drawn. (*PA*, 1959, #4833)

42. LAWS OF STATIC ELECTRICITY AND MAGNETISM IN AN ARBITRARY FRAME OF REFERENCE

Arzelies, H. and Henry, J.
***Comptes rendus hebdomadaires des séances de l'académie des sciences*, v. 247, no. 11, pp. 815–817, September 15, 1958 (in French)**

Relativistic electromagnetic equations are expressed as covariant equations in three space. An expression derived for the electric induction vector in an arbitrary frame involves the magnetic induction and polarization as well as the electric intensity vector. Application to static fields in a rotating medium is briefly considered. (*PA*, 1959, #462)

43. LAMINAR JET MIXING OF ELECTRICALLY CONDUCTING FLUID IN A TRANSVERSE MAGNETIC FIELD

Pai, S. J.
***Journal of the Aero/Space Sciences*, v. 26, p. 254 May–December 1959**

44. MAGNETIC FIELD EFFECTS ON BOW SHOCK STAND-OFF DISTANCE

Ziemer, R. W. and Bush, W. B.
***Physical Review Letters*, v. 1, no. 2, pp. 58–59, July 1958**

This note reports a comparison between some measurements on the displacement of a bow shock from a hemisphere and the calculated displacement. The calculations were based on a simplified model which consisted of an incompressible, inviscid isothermal fluid layer between the hemisphere and assumed hemispherical shock. The magnetic field was that of a dipole at the origin of the hemisphere. The dipole axis was parallel to the stream velocity ahead of the normal shock. The experimental results are presented as the fractional increase on the shock standoff distance as a function of a nondimensional parameter which is just the ratio of the square of the Hartmann number to the Reynolds number. Consequently, this parameter is proportional to the ratio of magnetic stress to dynamic fluid stress.

The comparison of the theory with experiment is good at low values of the magnetic stress but the theory tends to systematically overestimate the shock displacement when the magnetic stresses are much larger than the dynamic stresses.

The simplifications that have been introduced into the theoretical model contain several compensating factors. The data presented should be extremely valuable in studying the effects of the several assumptions. Thus, if a more accurate representation of Ohm's Law were used the agreement between calculation and measurement would be improved. It can be shown that the ion slip and Hall currents have the effect of reducing the effectiveness of the magnetic field in a manner that the data seems to follow. (*AMR*, 1959, #467)

45. LANGEVIN EQUATION AND THE A.C. CONDUCTIVITY OF NON-MAXWELLIAN PLASMAS

Molmud, P.
***The Physical Review*, v. 114, no. 1, pp. 29–32, April 1, 1959**

The use of the Langevin equation $\{dv/dt + gv = (q/m)[E_0 e^{iwt} + (v/c) \times H]\}$ to describe the electrical conductivity of a non-Maxwellian plasma (a weakly ionized gas in which the average electron collision frequency is temperature dependent) may be in error unless it is understood that the dissipative term, g, is complex. In the limiting cases of either high or low pressures the imaginary part of g is negligible. The real or imaginary parts of g are evaluated for these limiting cases, for four different gases: air, helium, Maxwellian gas, and water. The real part of g is shown to be the average collision frequency multiplied by a numerical factor, the size of which depends on the nature of the gas and the pressure limit. (*PA*, 1959, #7109)

46. KINETIC EQUATION FOR A PLASMA WITH UNSTEADY CORRELATIONS

Tehen, C. M.
***The Physical Review*, v. 114, no. 2, pp. 394–411, April 15, 1959**

As a generalization of the Boltzmann equation, the kinetic equation for a plasma is derived in the form of a generalized Fokker–Planck equation, by considering unsteady correlations, including non-Markovian and nonlinear behavior. Both the binary and ternary correlations are used for many kinds of particles with different temperatures. The coefficients of the kinetic equation depend on the law of interaction for a pair of particles and are influenced by relaxation. The effective potential of friction consists of two parts: the static part corresponds to

the Debye potential and is isotropic, the dynamical part is axially symmetrical about the direction of motion, and causes a dynamical friction.

The results show that the friction is proportional to velocity for slow particles, and inversely proportional to the square of velocity for fast particles. This tendency of the fast particles to overcome repulsion is a property connected with the "run-away" of electrons. A criterion for maximum friction is derived. The triplet interaction, which mainly affects the shielding phenomena, assures the convergence of the coefficients in case of distant interaction. Since the length scales of interaction are well determined in this way, the kinetic equation can be expected to be valid over a longer range than does the Boltzmann equation. The large scale agrees with the Debye radius when the shielding term is linearized as should be expected. When time relaxation is left aside and linearization is made, the kinetic degenerates to the classical Fokker–Planck equation with convergent coefficients. (*PA*, 1959, #8246)

47. ENERGY EQUATIONS OF MAGNETO-GAS-DYNAMICS
Pai, S.
***The Physical Review*, v. 105, no. 5, pp. 1424–1426, March 1957**
(*Applied Mechanics Reviews*, 1958, #528)

48. ESTIMATES OF THE TOTAL ENERGY IN PARTICLE AND MAGNETIC FIELD IN THE NON-THERMAL RADIO SOURCES
Burbridge, G. R.
***Astrophysical Journal*, p. 849, May 1959**

49. FLEXURE OF A TWO-DIMENSIONAL ARC UNDER FORCED CONVECTION
Thiene, P. G.
Giannini Plasmadyne Corporation, Santa Ana, Calif.
AF 49(638)-334, R-T-2TN089-334, AFOSR-TN-59-947, August 25, 1959

An inquiry is conducted into the nature of the physical mechanisms which maintain an arc in the presence of forced convection. The basic fluid-mechanical and electromagnetic equations are developed for the case of a dilute, three-component quasineutral arc plasma, and are applied to a simple model of a two-dimensional arc in a low-Mach number subsonic flow.

50. HIGH TEMPERATURE GAS DYNAMICS PHENOMENA IN HYPERSONIC FLIGHT
Wurster, W. H. and Treanor, C. E.
Symposium on High-Speed Aerodynamics and Structures (3rd), San Diego, Calif., March 25–27, 1958, v. 1, pp. 89–107
(*ARS Journal*, Technical Literature Digest, December 1959)

51. SHIELDING CORRECTION TO THE ELECTRICAL MICROFIELD IN A PLASMA AND TO HOLTSMARK'S THEORY OF LINE BROADENING
Hoffman, H. and Theimer, O.
***Astrophysical Journal*, p. 477, 1958**

52. HYDRODYNAMIC ANALYSIS OF THE COMPRESSION OF A RAREFIED PLASMA IN AN AXIALLY-SYMMETRIC FIELD
Barabanenkov, Iu. N.
***Soviet Physics–JETP*, v. 35, no. 8, p. 893, May 1959**
(*ARS Journal*, Technical Literature Digest, December 1959)

53. HYDROMAGNETIC EQUATIONS FOR TWO ISOTOPES IN A COMPLETELY IONIZED GAS
Slepian, J.
***The Physical Review*, v. 112, no. 5, pp. 1441–1444, December 1, 1958**

The hydromagnetic equation for a completely ionized gas of high density with a single isotope is derived. The difference between the accelerations of the isotopes at any internal point is then equal to $\delta M/M$ times $(1/\rho[j\times B]$ the force on the induced current per unit density due to the magnetic field. It is then shown that the ionic centrifuge gives almost no enrichment of the isotopes deposited, whereas the magnetoionic expander gives a very high enrichment. (*PA*, 1959, #4751)

54. HYDROMAGNETIC EQUILIBRIUM IV. AXISYMMETRIC COMPRESSIBLE MEDIA
Woltjer, L.
***Astrophysical Journal*, p. 405, September 1959**

55. IMPLICATIONS OF PARITY NONCONSERVATION AND TIME REVERSAL NONINVARIANCE IN ELECTROMAGNETIC INTERACTIONS. PART II: ATOMIC ENERGY LEVELS

Sachs, M. and Schwebel, S. L.

***Annals of Physics*, v. 8, pp. 475–508, 1959**

The implications of the parity nonconserving and time reversal noninvariant theory of electromagnetic interactions (which has been developed in a previous paper) with regard to the properties of atoms and their associated spectra, are investigated. In the first part of this paper, the modified Dirac equation for the hydrogen atom, in which the extra pseudo-vector part of the four potential (B_v) is included, is solved exactly. The solutions are found to depend on a new constant of the motion which replaces the conventional angular momentum operator. This new constant is made up in part of the conventional pseudo-vector angular momentum (particle) variable and in part of a vector function of the particle and field variables. The results are applied to a determination of new selection rules for magnetic and electric dipole transitions (which are forbidden in the conventional theory) and the calculation of the associated transition probabilities.

The contribution of the pseudo-vector four potential to the measured value of the Lamb shift is calculated.

The second part of this paper deals with the spectra of constituent magnetic ions of paramagnetic crystals.

56. IONIC THEORY OF PLASMAS AND MAGNETOHYDRODYNAMICS

Green, H. S.

***Physics of Fluids*, pp. 341–349, July–August 1959**

Derivation of a complete set of macroscopic equations based on ionic theory. (*A/SE*, November 1959)

57. A NOTE ON ONE-DIMENSIONAL PLASMA MOTION

Gross, R. A.

***Journal of the Aero/Space Sciences*, v. 25, no. 12, pp. 788–789 (Readers Forum), December 1958**

Author derives the change of a number of physical quantities from the magnetohydrodynamics equations, as a function of heat added during the motion. He shows that the behavior is characteristically different depending on whether a generalized Mach number (taking into account the magnetic effects upon the propagation of disturbances) is larger or smaller than unity. (*AMR*, 1959, #3630)

58. A POYNTING THEOREM FOR MOVING BODIES AND THE RELATIVISTIC MECHANICS OF EXTENDED OBJECTS

Meyers, N. H.

***Journal of Franklin Institute*, v. 266, no. 6, pp. 439–464, December 1958**

It is shown that in Chu's modified electrodynamics, which reduces to Maxwell's equations in a rest coordinate system, there is a Poynting-type theorem which can be interpreted physically even in the presence of moving media. (*PA*, 1959, #3651)

59. A SHALLOW-LIQUID THEORY IN MAGNETOHYDRODYNAMICS

Fraenkel, L. E.

California Institute of Technology, Guggenheim Aeronautical Laboratory, Pasadena

AF 49(638)-476, AFOSR-TN-59-563, June 1959 (ASTIA AD-216,758)

The nonlinear and linear "shallow-water" theories, which describe long gravity waves on the free surface of an inviscid liquid, are extended to the case of an electrically conducting liquid on a horizontal bottom, in the presence of a vertical magnetic field. The dish holding the liquid, and the medium outside it, are assumed to be nonconducting. The approximate equations are based on a small ratio of depth to wavelength, on the properties of mercury, and on a moderate magnetic field strength. Some explicit solutions of the linear equations are obtained for plane flows and for axi-symmetric flows in which the velocity vector lies in a vertical, meridianal plane.

60. AVTOMODEL'NYE DVIZHENIIA I TOCHECHNYI VZRYV V MAGNITNOI GAZODINAMIKE PRI BESKONECHNOI PROVODIMOSTI GAZA

Sharikadze, D. U.

***Akademii Nauk SSSR, Doklady*, pp. 1183–1186, August 21, 1959 (in Russian)**

Investigation of the motion of an infinitely conducting gas-magnetic medium, assuming that the energy of the magnetic field can be represented as entropy power function. Includes derivation of equations describing non-steady flow of gas in the magnetic field, where the force H is normal to the velocity of the gas; calculation of the point detonation, and the propagation of shock waves. (*A/SE*, December 1959)

61. AXIALLY SYMMETRIC SOLUTIONS OF THE MAGNETOHYDROSTATIC EQUATION WITH SURFACE CURRENTS
Biermann, L., et al.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 826–832, 1957 (in German)**

Solutions are derived for a plasma contained in a torus of circular cross-section, the electric current flow being confined to the surface. The magnetic field intensity is determined for given surface currents. It is shown that the currents must possess azimuthal components. (*PA*, 1959, #1605)

62. AXIAL-SYMMETRIC MAGNETOHYDRODYNAMIC STABILITY CONFIGURATIONS
Lüst, R. and Schlüter, A.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 850–854, 1957 (in German)**

It is shown that in equilibrium the gas pressure p and the toroidal part T of the magnetic field must be functions of the meridional part F. Assuming the forms of these functions, a differential equation for F is derived and solved, assuming that $T(F)$ is constant. The magnetic lines of force are then calculated numerically and sketched for a special case. Some remarks on the stability are added. (*PA*, 1959, #1606)

63. CERTAIN SOLUTIONS OF THE EQUATIONS OF PLASMA HYDRODYNAMICS
Vedenov, A. A.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* SSSR, v. 33, no. 6 (12), pp. 1509–1511, 1957 (in Russian)**
English translation in: *Soviet Physics–JETP*, New York, v. 6(33), no. 6, pp. 1165–1167, June 1958

Solutions are obtained describing the motion of a frictionless cold plasma in the following situations: (1) only H_z, E_x, v_x, v_y differ from zero, H_z is constant, and the other variables depend on x and t only; (2) only H_z, E_r, v_r, v_ϕ differ from zero, H_z is constant and the other variables depend on r and ϕ only. The dependent variables have the form e^{-t/t_0} times a function of $[t_1 t_0 + \ln(x/x_0)]$ or $[t/t_0 + \ln(r/r_0)]$. The solutions appear to describe travelling plasma oscillations of finite amplitude. (*PA*, 1959, #7114)

64. CHARACTERISTIC MANIFOLDS IN THREE DIMENSIONAL UNSTEADY MAGNETO-HYDRODYNAMICS
Ong, R. S.
***Physics of Fluids*, pp. 247–251, May–June 1959**

Application of a technique developed in the general theory of discontinuities to the basic equations of unsteady magnetohydrodynamics in order to find the conditions to be satisfied by the discontinuities in the derivation of the significant flow and magnetic field parameters. With the aid of relations satisfied by the jumps in the derivatives of the parameters the various characteristic manifolds are found. Finally, it is shown that these manifolds are hypersurfaces along which small disturbances and weak shocks are propagated. (*A/SE*, September 1959)

65. CONCEPTS OF MOVING ELECTRIC AND MAGNETIC FIELDS IN MAGNETO-HYDRODYNAMICS
McCune, J. E. and Sears, W. R.
***Journal of the Aero/Space Sciences*, v. 26, pp. 674–675, October 1959**
(*Applied Science and Technology Index*, December 1959)

66. CONDUCTIVITY OF A WARM PLASMA
Mower, L.
***The Physical Review*, Second Series, v. 116, no. 1, p. 16, October 1, 1959**

67. AN INVESTIGATION ON PLASMAS IN EXTERNAL MAGNETIC FIELDS II. VARYING FIELDS
Schmidt, G.
***Il Nuovo Cimento*, v. 10, no. 4, pp. 659–674, November 16, 1958**

The behavior of a plasma placed in a varying-external

magnetic field is investigated considering two limiting cases: (1) the ideal hydromagnetic ($\sigma \to \infty$); (2) the collisionless one. Restricting the calculations to general cylindrical geometries ($\partial/\partial z = 0$) and quasi-stationary processes, a complete set of plasma equations are obtained for both cases. These include among others equations of state also for the tenuous plasma. There is a close resemblance between the two sets of equations referring to completely different physical conditions. The equations can be readily solved to express every macroscopic plasma quantity in terms of the external magnetic field strength. The extension of these considerations to non-quasi-stationary processes is briefly depicted. It leads to a phenomenon which suggests new ways for the increase of plasma temperatures. (For Part I see *PA*, 1959, #2431.) (*PA*, 1959, #3596)

68. DISCONTINUITY SURFACES IN MAGNETO-FLUID-DYNAMICS

Napolitano, L. G.
Brooklyn Polytechnic Institute, Aeronautical Engineering and Applied Mechanics Dept., N. Y.
Report 503, December 1958
AFOSR TN 59-67
(ASTIA AD-209,842)

This report is concerned with the macroscopic study of magneto-fluid-dynamic discontinuities for negligible relativistic effects. Jump conditions relating the end states on the two sides of discontinuity surfaces of arbitrary geometry are derived for both the steady and unsteady cases. Applications are presented in connection with (a) the magneto-fluid-dynamic counterpart of the Truesdell–Lighthill–Hayes problem of determining the vorticity jump across a shock, and (b) the existence of magneto-fluid-dynamic slip and/or contact surfaces. (*AMR*, 1959, #6323)

69. DISTURBANCES IN A MULTI-VELOCITY PLASMA

Pierce, J. R. and Morrison, J. A.
***IRE Transactions on Electron Devices*,**
N. Y., Vol. ED-6, no. 2, pp. 231–236, April 1959

The single-velocity treatment of ac disturbances in electron flow is often accurate enough even when the flow actually has an infinitely broad but peaked velocity distribution, such as a Maxwellian, or a bell-shaped distribution. In seeking a better approximation, one is tempted to expand in terms of the moments of the velocity distribution and to disregard terms beyond that involving the second moment. This leads to a dispersion equation describing waves which strictly do not exist. A linearized analysis by transform methods predicts a field which oscillates in an exponentially damped manner. This is not the oscillation of a normal mode, however, for various velocity classes of the charge distribution have ac densities which grow with time. This indicates that the linear expression will hold over a finite interval only. A simple example which compares a multistream analysis with an analysis based on the charge density in phase space (the distribution function) indicates the same sort of failure of both of the linearized theories at large times. Thus, it appears that the failure is characteristic of the problem rather than of the method of solution. The method of solution is a matter of choice. (*PA*, 1959, #9726)

70. DYNAMICS OF A DISSOCIATING GAS. III. NON-EQUILIBRIUM THEORY

Freeman, N. C.
North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Paris
AGARD-R-133, July 1957

The equilibrium theory of an ideal dissociating gas discussed by Lighthill (1956) is extended to non-equilibrium thermo-dynamic conditions by postulating a rate equation for the dissociation process (including the effects of recombination). The behavior of the gas in flow through strong normal shock waves and past bluff bodies is studied under non-equilibrium conditions.

71. A NOTE ON FORCE-FREE FIELDS

Majumdar, S. K.
***Zeitschrift für Astrophysik*, Berlin,**
v. 47, no. 1, pp. 44–49, 1959

Considers a magnetohydrostatic field in an infinitely conducting incompressible medium, the field becomes force-free due to suitable displacement of the medium. An expression for the "modes" of displacement is obtained. (*PA*, 1959, #4842)

72. A NOTE ON MAGNETO-HYDRODYNAMICS OF A FINITE ROTATING DISK
Majumdar, S. K.
***Zeitschrift für angewandte Mathematik und Physik*, v. 9a, no. 4, pp. 387–389, November 1958**
(*Applied Mechanics Reviews*, 1959, #4727)

73. AN INVESTIGATION ON PLASMAS IN EXTERNAL MAGNETIC FIELDS. I. STEADY STATE
Schmidt, G.
***Il Nuovo Cimento*, v. 10, no. 1, pp. 55–67, October 1, 1958**

The stationary state of a magnetically confined neutral plasma is investigated. For a rare plasma, without particle collisions, a method is developed by which a complete set of plasma equations is established. This is based upon the simultaneous solution of Maxwell's equations and the equations of the particles. As application of this method, generalized forms of the pressure balance equations are derived. An alternative treatment of this relation on the basis of the Boltzmann equation leads to a general expression valid also for cases when collisions are not negligible. As an example, the plasma equations are solved for a problem for which the usual first-order theory breaks down. (*PA*, 1959, #2431)

74. A NEW PRINCIPLE OF EXISTENCE OF HIGH-TEMPERATURE PLASMOIDS
Vlasov, A. A.
***Scientia Sinica*, v. 8, no. 3, pp. 266–287, March 1959 (in Russian)**

The "plasmoids" dealt with theoretically here are cylindrically symmetrical distributions of positively charged particles concentrated mainly near the axis. The disruptive effect of electrostatic, pressure and centrifugal forces, is balanced by a Lorentz force due to the interaction of rotation of the plasmoid with an external axial magnetic field. The structure of the plasmoid is deduced from the collision-free Boltzmann equation, on the assumption that the velocity distribution is like the Maxwell distribution. An "equation of state" for the plasmoid is derived; this equation relates the temperature of the plasmoid to the particular mass, the diameter of the plasmoid, and the Larmor and plasma frequencies. Temperatures of 10^{10} to 10^{12} degrees could be attained, without large electric currents, by this method, provided the magnetic field is large and the density small. (*PA*, 1959, #9729)

75. AN ENERGY PRINCIPLE FOR HYDROMAGNETIC PROBLEMS
Bernstein, I. B.
***Proceedings of the Royal Society of London*, v. 244A, pp. 17–40, February 25, 1958**
(*Jet Propulsion*, Technical Literature Digest, 1958)

76. AN AXIOMATIZATION OF MAXWELL'S THEORY OF THE ELECTROMAGNETIC FIELD
Horváth, J. I.
***Acta physica Hungarica*, v. 8, no. 4, pp. 399–418, 1958 (in German)**

An attempt is made to present the experimental basis of Maxwell's theory in axiomatic form. (*PA*, 1959, #1592)

77. A MICROSCOPIC ANALYSIS OF MAGNETO-GAS-DYNAMICS
Covert, E. E.
Third Biennial Gas-Dynamics Symposium, Evanston, August 24–26, 1959
Massachusetts Institute of Technology, Cambridge NSL TR 395, 1959 (42 pp, 45 ref.)

Discussion of the kinetic theory approach to magnetogasdynamics. Several methods for considering interactions, in which the long range forces are of importance, are compared critically. The effects of the magnetic field on the particle interactions and their trajectories are shown to introduce anisotropies in magnetogasdynamics. The effects of these anisotropies are briefly discussed.

78. A METHOD OF SOLUTION OF THE EQUATIONS OF MAGNETOHYDRODYNAMICS
Blankfield, J. and McVittie, G. C.
***Archive for Rational Mechanics and Analysis*, pp. 411–422, February 4, 1959**

Solution of equations describing the motion of a gas cloud with infinite plane faces normal to the direction of motion, the forces being the pressure gradient and a magnetic force parallel to the faces. The theory depends on degenerating Einstein's equations of general relativity. In this method, the indeterminate functions are known to be degenerate forms of the generalized potentials of Newtonian theory. The pressure and density vanish on the plane faces, the motion is adiabatic, and the ratio of specific heats has the value of 1.5. The gas cloud expands, but not beyond a certain finite width. Ultimately, the

binding effect of the magnetic field balances the disruptive effect of the pressure gradient, and the cloud approaches equilibrium. (*A/SE*, August 1959)

79. A LAGRANGIAN FORMULATION OF THE BOLTZMANN-VLASOV EQUATION FOR PLASMAS

Low, F. E.
***Proceedings of the Royal Society of London*, Series A, v. 248, pp. 282–289, November 11, 1958**
(*ARS Journal*, Technical Literature Digest, October 1959)

80. A CLASS OF EXACT SOLUTIONS OF THE MAGNETOHYDRODYNAMIC NAVIER-STOKES EQUATIONS

Wu, C.-S.
Princeton University, Aeronautical Engineering Dept., N. J.
R-436, September 1958
AF 18(600)-498; AFOSR-TN-58-895
(ASTIA AD-204,134)

A class of similarity solutions of the magnetohydrodynamic Navier–Stokes equations have been found in this paper so that the original differential system may reduce to two ordinary differential equations. The equation governing the velocity field appears to be of first order but with a nonlinear interaction term of the magnetic field. The magnetic induction equation is of second order.

81. A CLASSICAL THEORY OF THE CREATION AND ANNIHILATION OF ELECTRIC CHARGES

Durand, E.
***Annales de la Faculté des Sciences de l'Université de Toulouse*, v. 20, pp. 99–110, 1956 (in French)**

Proposes a generalization of the classical Maxwell–Lorentz equations in which charge is not conserved. (*PA*, 1959, #463)

82. EFFECTS OF GRAVITATIONAL OR ELECTROMAGNETIC FIELDS ON FLUID MOTION

Yih, C. S.
***Quarterly of Applied Mathematics*, v. 16, no. 4, pp. 409–415 (Notes), January 1959**

Extension of Proudman–Taylor's theory concerning the two-dimensional character of a weak steady rotational motion to motions with gravitational, magnetic and electric fields. In all cases, for weak steady motion, the effect of the gravitational, magnetic or electric field is to "stiffen" the flow along two-dimensional surfaces like the rotational flow stiffens the weak flow along vorticity lines.

The mathematical analysis is carried out for all four cases. (*AMR*, 1959, #4725)

83. EQUATIONS OF ELECTRODELESS RING DISCHARGE AND THEIR SOLUTION FOR THE BREAKDOWN CRITERION

Eckert, H. U.
CONVAIR, Scientific Research Laboratory, San Diego, Calif.
Research R-5, August 1959

For a long cylindrical tube in which a discharge is maintained at medium pressure and moderate input by induction from a surrounding solenoid, differential equations are derived for the distributions of magnetic field H, induced electric field E and conductivity σ. Diffusion is considered the dominant-loss factor for electrons, their collision frequency is taken constant, and their spatial energy distribution as determined by that of E. An approximate analytical solution is obtained for the case of vanishing σ at breakdown where H is constant and E proportional to distance from axis.

84. ELECTROMAGNETIC EQUATIONS WRITTEN IN A FORM INDEPENDENT OF THE SYSTEM OF UNITS

Berreman, D. W.
***American Journal of Physics*, v. 27, no. 1, pp. 44–46, January 1959**

This paper illustrates a form for writing electromagnetic equations such that by substituting the appropriate value for each of two arbitrary constants one immediately obtains the electromagnetic equations written in any of the consistent systems of units. One constant is a dimensionless term called a rationalizing factor that takes the value 4π in unrationalized systems and unity in rationalized systems. The other is ϵ_0, the capacity of free space. Except for the rationalizing factor, all equations are identical in appearance with equations written in the rationalized M.K.S.Q. system of units. Maxwell's equations and some other commonly used relations are presented in this form. A simple method of obtaining the

equations in the Gaussian and the Heaviside–Lorentz mixed systems of units from the form presented for consistent systems is also given. (*PA*, 1959, #1591)

85. SHIELDING CORRECTION TO THE ELECTRICAL MICROFIELD IN A PLASMA AND TO HOLTSMARK'S THEORY OF LINE BROADENING

Hoffman, H. and Theimer, O.
***The Astrophysical Journal*, p. 477,**
January–May 1958

86. ELECTRODIELECTRIC INDUCTION

de BeLatini, P.
***Bulletin of the Technical University of Istanbul*,**
v. 10, no. 1, pp. 84–111, 1957

Continuing the work presented in a previous paper (*PA*, 1954, #7099) this report dwells on analogies between magnetic and dielectric quantities and laws, and formulates, in particular, the law of "electrodielectric induction." The underlying idea is to introduce the concept of a dielectric circuit in analogy to the magnetic circuit. (*PA*, 1959, #1594)

87. ELECTRO-GAS DYNAMIC MOTION OF A CHARGED BODY IN A PLASMA

Kraus, L. and Yoshihara, H.
International Astronautical Society (IAS),
27th Annual Meeting, New York, January 26–29, 1959
Report 59–75

Analysis of some aspects of the coupling between fluid motion and the electrostatic properties of a plasma. The basic equations are described and the theory illustrated by treating the very simple case of supersonic flow of a plasma past a two-dimensional slender dielectric body. A simplification requires that the "boundary layers" are defined as narrow regions in which the electrostatic potential and the flow properties change rapidly. The precise analysis of the effects would require the use of the complete fourth-order system of differential equations. These equations are twofold hyperbolic and twofold elliptic when the motion of the body is supersonic with respect to the ion thermal velocity.

This property manifests itself by an upstream effect ahead of the leading edge Mach wave which dampens exponentially. Electrical effects instead of influencing the entire medium are confined essentially to a region downstream of an electrostatic Mach envelope. (*A/SE*, March 1959)

88. ON HYDRODYNAMIC STABILITY OF UNLIMITED ANTISYMMETRICAL VELOCITY PROFILES

Curle, N.
Astronautical Research Council, Great Britain,
Fluid Motion Sub-Committee
R-18, 564, July 10, 1958
R-F.M. 2431

It is shown how the problem of hydrodynamic stability for the general unlimited anti-symmetrical velocity profile may be reduced to that of finding the inviscid solution of the Orr–Sommerfeld equation and evaluating certain non-singular integrals along the real axis. The curve of neutral stability is calculated for one of a family of velocity profiles for which analytic inviscid solutions of the Orr–Sommerfeld equation are derived.

89. ON SOME FUNDAMENTALS IN MAGNETO-FLUID-MECHANICS

Covert, E. E.
Massachusetts Institute of Technology, Cambridge,
Naval Supersonic Laboratory
TR-247

The basic equations of magneto-fluid-mechanics are derived from classical kinetic theory for a gas consisting of neutral particles, positive particles (ions) and electrons. Included are the equations of conservation of mass and momentum for each type of particle, an energy equation, the Maxwell equations of electrodynamics, and suitable state equations. The basic equations are normalized and the resulting dimensionless parameters are discussed briefly.

90. ON THE CONCEPTS OF MOVING ELECTRIC AND MAGNETIC FIELDS IN MAGNETOHYDRODYNAMICS

McCune, J. E. and Sears, W. R.
***Journal of the Aero/Space Sciences*, v. 26, no. 11,**
pp. 674–675, October 1959

91. ON THE EQUATION OF THE ELECTRO-MAGNETIC MOMENTUM IN THE ELECTRODYNAMICS OF MOVING BODIES

Carini, G.

Atti della Società Peloritana di Scienze Fisiche Matematiche e Naturali, Università di Messina, Messina, v. 2, no. 4, pp. 283–291, 1955–1956 (in Italian)

Starting from Minkowski's electromagnetic equations for moving bodies, the expression for the electromagnetic momentum is deduced from the energy theorem and from the principle of (special) relativity. (*PA*, 1959, #1593)

92. ON THE FUNDAMENTAL EQUATIONS OF MAGNETOHYDRODYNAMICS AND SOME OF THEIR APPLICATIONS
Carstoiu, J.
Comptes rendus hebdomadaires des séances de l'académie des sciences, v. 247, no. 20, pp. 1716–1718, November 17, 1958 (in French)

The equations for a uniform liquid of finite conductivity and uniform charge density are expressed in terms of Lagrange variables defining the motion of individual particles of the liquid. It is shown that a charged liquid particle with initial vorticity would create a magnetic field whose intensity increased with time. Speculations are made concerning the relevance of this result to the problem of terrestrial magnetism. (*PA*, 1959, #2518)

93. ON THE MOTION OF A CHARGED PARTICLE IN AN ANISOTROPIC MEDIUM
Begiashvili, G. A. and Gedalin, E. V.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, SSSR, v. 35, no. 6(12), pp. 1513–1517, 1958 (in Russian)

Expressions for the electromagnetic field components are derived and the total energy losses are determined for a charged particle moving in an anisotropic gyroelectric and gyromagnetic medium. (*PA*, 1959, #12508)

94. ON THE POSSIBLE EXISTENCE OF CONSERVATIVE SYSTEMS OF ELECTRIC CHARGES WITH NON-STATIONARY FIELDS IN THE CLASSICAL THEORY OF ELECTRODYNAMICS
Bomze, J.
Osterreichische Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse, Sitzungsberichte, Abteilung II, v. 165, no. 8–10, pp. 313–325, 1956 (in German)

It is shown that the mathematical description of an electrodynamic system in which the field varies in time, but does not radiate energy, must contain both the retarded potential solution and the advanced potential solution. The arguments which have been used for regarding the advanced potential solution as physically impossible are criticized. (*PA*, 1959, #1595)

95. ON THE RECIPROCAL ACTION ENERGY OF CHARGE CARRIERS IN A PLASMA
Theimer, O.
Zeitschrift für Naturforschung, v. 13a, no. 7, pp. 568–569, July 1958 (in German)

A very brief discussion of certain aspects of the Debye–Hückel theory of electrolytes, as applied to plasmas. For example the Debye shielding distance is introduced. (*PA*, 1959, #4749)

96. ON THE SURFACES OF DISCONTINUITY IN THE MAGNETO-FLUID-DYNAMICS
Napolitano, L. G.
L'Aerotecnica, v. 38, pp. 210–220, August 1958 (in Italian)
(*ARS Journal*, November 1959)

97. ON THE THEORY OF TRANSPORT PHENOMENA IN DISCHARGES AT HIGH CURRENT DENSITIES
Schirmer, H.
Zeitschrift für Naturforschung, v. 14a, no. 4, pp. 318–323, April 1959 (in German)

A theory of transport phenomena is developed for the case of a discharge plasma with an appreciable self-magnetic field and acted upon by a longitudinal magnetic field. The formulae are derived for a Lorentz gas. (*PA*, 1959, #12404)

98. PENETRATION OF A MAGNETIC FIELD INTO A ONE DIMENSIONAL PLASMA
Ron, A.
Il Nuovo Cimento, v. 10, no. 5, pp. 844–853, December 1, 1958

In connection with the proposed compression and heating of a plasma through the application of an external magnetic field arises the problem of the penetration of

such a field into a plasma. It is here investigated how an external magnetic field penetrates into a one dimensional bounded plasma which behaves as a compressible hydromagnetic fluid whose conductivity is proportional to density. The resulting mathematical problem is complicated, in particular as the movement of the boundary is not known before hand. Transformation to a system of coordinates moving with the fluid simplifies the equations. In particular, in the case of a slowly varying magnetic field a single equation obtains with the magnetic field as the only independent variable. (*PA*, 1959, #3597)

99. PENETRATION OF TRANSIENT ELECTROMAGNETIC FIELDS INTO A CONDUCTOR
Grumet, A.
***Journal of Applied Physics*, v. 30, no. 5, pp. 682–686, May 1959**

The case of a uniform electric field, infinite in extent, abruptly applied to the plane face of a semi-infinite conductor is considered. The amplitude of the field as a function of distance into the conductor and of time is then determined for different conductivities. The time element and distance for ignoring the displacement current term in Maxwell's equations is determined. Finally, the time and space nature of the applied electric field at distances far removed from the semi-infinite conductor is considered. (*PA*, 1959, #7204)

100. PHYSICAL GAS DYNAMICS RESEARCH AT THE AVCO RESEARCH LABORATORY
Rose, P. H.
North Atlantic Treaty Organization, Paris, Advisory Group for Aeronautical Research and Development, July 1957
AGARD-R-145

101. PLANE PROBLEMS IN MAGNETOHYDRODYNAMICS
Golitsyn, G. S.
***Soviet Physics-JETP*, v. 7, no. 3, pp. 473–477, September 1958**
(Translation of *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, no. 3, pp. 688–693, March 1958 by American Institute of Physics, Inc., N.Y.)

Conditions for the potential flow of an inviscid fluid with infinite electrical conductivity are set forth briefly. Attention is then turned to motion in a plane perpendicular to the magnetic field; a nonstationary generalization of magnetohydrodynamic Prandtl–Mayer motion is introduced; and finally the magnetohydrodynamic Prandtl–Mayer problem is discussed in some detail, with a presentation of various results. (*AMR*, 1959, #6338)

102. PLASMAS AND THE ELECTROMAGNETIC FIELD
Bachynski, M. P., et al.
Canadian Armament Research and Development Establishment, Quebec
CARDE-TM-AB-26, January 1959
(PCC-D46-95-51-10)

A fundamental review of plasma physics with special emphasis on interaction of electromagnetic waves with plasmas is attempted. The basic ideas of the motion of charged particles comprising a plasma gas are presented and followed by more rigorous formulations. The interactions of the atomic gas constituents are considered and their effects assessed under various conditions. Electromagnetic wave interaction is introduced through Maxwell's equations for both uniform and non-uniform plasmas. Finally, microwave measurements and techniques for determining plasma properties, their utility and limitations are discussed.

103. RALEIGH'S PROBLEM IN HYDROMAGNETICS: IMPULSIVE MOTION OF A POLE-PIECE
Ludford, G. S. S.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN BN-151
(AFOSR TN 58-1073), November 1958
(ASTIA AD-207,242)

Analysis of the motion of an incompressible, viscous, electrically conducting fluid contained between the parallel, plane pole-pieces of a permanent magnet which provides a uniform external field in the y-direction. Starting at time $t = 0$, with the fluid at rest, the magnet is made to move uniformly in the negative x-direction. A simple exact solution is presented for which the transition from zero to infinite conductivity is traced and the modifying effects of viscosity determined. (*A/SE*, March 1959)

104. RAYLEIGH'S PROBLEM IN MAGNETO-HYDRODYNAMICS

Chang, C. C. and Yen, J. T.
***Physics of Fluids*, pp. 393–403, July–August 1959**
(20 ref.)

USAF-supported extension of Rayleigh's problem to magnetohydrodynamics for the case of a perfectly conducting plate with a transversely applied magnetic field. Induced electric and magnetic fields are both included in the analysis. Results obtained show that along the plate an electromagnetic body force will act in the direction of fluid motion. The results are found to be the same whether the applied magnetic field is fixed in space or attached to the moving plate. A comparison of these results with those of Rossow (magnetic field fixed with fluid) shows opposite trends in the velocity profile. Such discrepancies are discussed. (*A/SE*, October 1959)

105. SELF-CONFINING MOTION OF A CONDUCTING GAS IN A MAGNETIC FIELD

Korobeinikov, V. P.
***Doklady Akademii Nauk SSSR*, v. 121, no. 4, pp. 613–615, 1958 (in Russian)**

Equations for the gas plasma are established in a form which clearly demonstrates the coupling between internal and external magnetic fields via the charge and particle densities and their space and time derivatives. Stability criteria are defined and a "locus of critical coupling" is derived to satisfy these criteria. (*PA*, 1959, #7108)

106. SOLUTION OF MAXWELL'S EQUATIONS IN TERMS OF A SPINOR NOTATION: THE DIRECT AND INVERSE PROBLEM

Moses, H. E.
***The Physical Review*, v. 113, no. 6, pp. 1670–1679, March 15, 1959**

Maxwell's equations for fields with sources in media in which the dielectric constant and permeability are unity, are written in terms of a spinor notation which resembles the one used on Dirac's equation for the electron. One can introduce Green's functions and expansions in terms of complete sets of orthogonal functions analogous to those used in the quantum theory of the electron, to solve Maxwell's equations in more compact form than in terms of the conventional vector notation. In addition, the new notation enables one to solve in a simple way an "inverse radiation problem" which is described as follows. Consider at time $t < 0$ the electromagnetic field to be zero. At time $t = 0$ sources are turned on and then later turned off. The electromagnetic field, which results after this process has been completed, will be a radiation field. One can solve the problem of finding the nature of the sources which will lead to a prescribed final radiation field. It is shown that, in general the sources are not unique but additional conditions can be given which will make them so. (*PA*, 1959, #7206)

107. SOME PROBLEMS OF MAGNETOGASDYNAMICS WITH ACCOUNT OF FINITE CONDUCTIVITY

Carrier, G. F.
***Soviet Physics—JETP*, v. 6, no. 6, pp. 1090–1099, June 1958 (Translation of *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 33, pp. 1417–1427, December 1957, by American Institute of Physics, Inc., N.Y.)**

All problems discussed are strictly one-dimensional with all equations satisfied, i.e., transverse electric and magnetic fields are not freely assignable but satisfy Maxwell's equations (contrast Resler and Sears, *Journal of the Aeronautical Sciences*, v. 25, p. 235, 1958). For most of the paper ideal gas law is assumed. Authors first show that unsteady one-dimensional flow is governed by parabolically degenerate equations when conductivity is finite. An approximation of dubious value permits a return to hyperbolic equations. Authors then consider steady motions and criticality of *ordinary* sound speed are pointed out. The augmented magnetohydrodynamic sound speed is significant only if the quantity (field/density) is constant. This is not the case with finite conductivity. Applicability of authors' work seems limited because all quantities must vary within lengths of order (magnetic diffusivity/velocity), i.e., the thickness of diffuse magnetic shocks. Authors go on to consider magnetic shock structure ignoring viscosity and thermal conductivity, with results similar to Burgers (*AMR*, 1958, #2663) and others. They also consider effect of finite conductivity on weak acoustic waves (*AMR*, 1959, #2657)

108. SOME SOLUTIONS OF THE MACROSCOPIC EQUATIONS OF MAGNETO-HYDRODYNAMICS

Sears, W. R.

American Rocket Society, N.Y.
August 24–26, 1959
P-899-59

A report is made on three different theoretical investigations concerning MHD of inviscid incompressible fluids. These three studies concern the following cases: (1) thin airfoils and slender bodies in fluids of moderate conductivity; this pertains to flows having uniform, parallel magnetic and velocity fields in the undisturbed region; (2) an inviscid magnetic boundary layer, and (3) some flows involving tensor conductivity.

109. STABLE ORBITS OF CHARGED PARTICLES IN AN OSCILLATING ELECTROMAGNETIC FIELD

Weibel, E. S.
Space Technology Labs., Inc., Los Angeles, Calif.
R-GM-TR-0165-00481, September 25, 1958
AF 04(647)-165

Orbits in a field of the cylindrical wave guide driven in the TE_{01}-mode have been studied. The radial components of the Lorentz force acting on the particle is never positive regardless of its charge: thus, it is attracted toward the axis of the wave guide around which the orbits are stable, that is, remain bounded for all times.

110. STATIONARY RELATIVISTIC MOTIONS OF A GAS IN A CONDUCTING MEDIUM

Staniukovich, K. P.
Soviet Physics–JETP, v. 35(8), no. 3,
pp. 529–531, March 1959
(*ARS Journal*, Technical Literature Digest,
October 1959)

111. STATISTICAL DERIVATION OF THE DISPERSION FORMULA OF A LORENTZ PLASMA OF FINITE TEMPERATURE

Rawer, K. and Suchy, K.
Annals of Physics, Leipzig Folge 7, v. 2,
no. 5–6, pp. 313–315, 1958 (in German)

Extends and solves the Boltzman equation for electrons by taking into account a previously neglected term to obtain a dispersion equation for three types of broadening. (*PA*, 1959, #3591)

112. STATISTICAL-MECHANICAL THEORY OF IRREVERSIBLE PROCESSES I. GENERAL THEORY AND SIMPLE APPLICATIONS TO MAGNETIC AND CONDUCTION PROBLEMS

Kubo, R.
Journal of the Physical Society of Japan,
v. 12, no. 6, pp. 570–586, June 1957

The principles and formalism of quantum statistical mechanics are reviewed and extended to include fluctuation-dissipation phenomena. Thus the gap between the equilibrium theory or statistical mechanics and the non-equilibrium theory of fluctuations is bridged. A rigorous and elegant explanation of the Onsager symmetry rules, a generalization of the Einstein relations connecting conductivity or mobility with a diffusion constant and illustrations by simple examples of magnetic and conduction problems are presented. (*AMR*, 1959, #2090)

113. STATISTICAL-MECHANICAL THEORY OF IRREVERSIBLE PROCESSES II. RESPONSE TO THERMAL DISTURBANCE

Kubo, R., Yokota, M., and Nakajima, S.
Journal of the Physical Society of Japan,
v. 12, no. 11, pp. 1203–1211, November 1957

The general quantum mechanical and fluctuation-dissipation concepts presented in Part I of this paper (*AMR*, 1959, #2090) are tested to yield rigorous relations for kinetic coefficients, such as thermal conductivity, the diffusion constant, thermoelectric power, which can be expressed in terms of generalized forces. A rigorous basis for the Onsager relationships is established and the theory is illustrated by an example from electronic transport phenomena. (*AMR*, 1959, #2091)

114. THEORY OF THRESHOLD ENERGY DEPENDENCE OF PHOTODETACHMENT OF DIATOMIC MOLECULAR NEGATIVE IONS

Geltman, S.
The Physical Review, v. 112, no. 1, pp. 176–178,
October 1, 1958

The energy dependence near zero energy of the continuum wave function of an electron in a molecular potential field is found by an iterative solution of the wave equation. This leads to shapes for the photodetachment

cross section near threshold which are found to depend on whether the molecular ion is heteronuclear or homonuclear and on the u, g symmetry (for homonuclear case) of the outer molecular orbital. The predicted energy dependences are found to be consistent with the available experimental data. (*PA*, 1959, #3608)

115. THE INTEGRATION OF LINEARIZED EQUATIONS OF MAGNETOHYDRODYNAMICS

Canobbio, E. and Croci, R.
Institute Nazionale di Fisica Nucleare, Milan, Italy
***Il Nuovo Cimento*, (10) v. 12, pp. 173–176, April 16, 1959 (in Italian)**

In the preceding paper (*Il Nuovo Cimento* (10) v. 12, p. 167, 1959) a method was given for the reduction of magnetohydrostatic equations for a cylinder or circular torus to a nonlinear integro-differential equation. It is shown that by linearizing the equation obtained the system can be reduced to a linear differential equation. The integration of this equation and the comparison with the solutions of magnetohydrostatic systems is only possible numerically. (*NSA*, 1959, #16530)

116. THE INTEGRATION OF THE EQUATIONS OF MAGNETOHYDROSTATICS FOR CONFIGURATIONS WITH AXIAL SYMMETRY

Canobbio, E. and Croci, R.
Institute Nazionale di Fisica Nucleare, Milan
***Il Nuovo Cimento*, (10) v. 12, pp. 167–172, April 16, 1959 (in Italian)**

A method to reduce the integration of the equation of magnetohydrostatics for a cylinder and a circular torus to that of a non-linear integro-differential equation is given. The equations obtained can be integrated numerically, and the stability of the solutions with respect to small variations in the conditions of the border can also be studied, (*NSA*, 1959, #16529)

117. THE HELICOIDAL STRUCTURES IN THE COSMIC ELECTRODYNAMICS

Akasofu, S. I.
***Tellus*, v. 10, no. 4, pp. 409–414, November 1958**

The general-type solutions of the equation [curl (curl $H \times H$)] $= 0$ are studied in the cylindrical systems, according to Lundquist's and Chandrasekhar's methods. In general, the magnetic fields are of helicoidal type in the cylindrical systems. Several examples are studied in the cosmical fields. (*PA*, 1959, #2521)

118. THE GREEN'S FUNCTION FOR MAXWELL'S (ELECTROMAGNETIC) EQUATIONS FOR INHOMOGENEOUS MEDIA

Khizhnyak, N. A.
***Zhurnal Tekhnicheskoi Fiziki*, v. 28, no. 7, pp. 1592–1609, 1958 (in Russian)**
(*Physics Abstracts*, 1959, #464)

119. THE EQUILIBRIUM OF A SELF-GRAVITATING INCOMPRESSIBLE FLUID SPHERE WITH MAGNETIC FIELD

Bhatnagar, P. L.
***Indian Institute of Science Journal*, Section A, pp. 50–73, April 1958 (11 ref.)**

(Abstracted in *Aero/Space Engineering*, October 1958)

120. AXIALLY SYMMETRIC SOLUTIONS OF THE MAGNETOHYDROSTATIC EQUATION WITH SURFACE CURRENTS

Biermann, L., et al.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 826–832, 1957 (in German)**

Solutions are derived for a plasma contained in a torus of circular cross section, the electric current flow being confined to the surface. The magnetic-field intensity is determined for given surface currents. It is shown that the currents must possess azimuthal components. (*PA*, 1959, #1605)

121. THE DISSIPATION OF MAGNETIC ENERGY IN AN IONIZED GAS

Cowling, T. G.
***Monthly Notices of the Royal Astronomical Society*, London, v. 116, no. 1, pp. 114–124, 1956**

A general formula is derived for the rate of dissipation of magnetic energy in an ionized gas. The formula is used to confirm Piddington's (*PA*, 1955, #9779, #9781) value for the conductivity effective in producing dissipation. It is shown that, contrary to Piddington's assertions, an effective electric force must be taken into account

when considering currents in the presence of a pressure gradient; however, this effective electric force has little effect on the dissipation. Piddington's results are completed by a general discussion of conductivity of a partially ionized gas. The results are applied to dissipation in interstellar gas; the effect of the magnetic field on the conductivity is shown to increase the rate of dissipation up to a point where the dissipation is not insignificant. (*PA*, 1958, #2419)

122. THE AXISYMMETRIC SELF-EXCITED FLUID DYNAMO

Backus, G.

***The Astrophysical Journal*, v. 125, no. 2, pp. 500–524, March 1957**

The behavior of axisymmetric magnetic fields maintained by electric currents in electrically conducting fluids of finite volume executing axisymmetric motion is studied at length. It is shown that the fluid motion cannot indefinitely increase any of the external multipole moments of the field, cannot prevent the decay of the external dipole moment, and cannot lengthen the decay time of the dipole moment by a factor of more than about 4 over its decay time in the absence of fluid motions. It is also shown that a certain weighted space average of the internal magnetic energy decays like the external dipole moment. When the fluid velocity is very high, an asymptotic expression for the rate of decay of the toroidal field is given. One application of these results is that if the geomagnetic field is maintained by a self-excited dynamo, the absence of axisymmetry of the field is probably essential to its generation and maintenance. (*PA*, 1958, #2422)

123. SWEET'S MECHANISM FOR MERGING MAGNETIC FIELDS IN CONDUCTING FLUIDS

Parker, E. N.

***Journal of Geophysical Research*, v. 62, no. 4, pp. 509–520, December 1957**

Sweet's mechanism (Proceedings of the International Astronomical Union Symposium on Electromagnetic Phenomena in Cosmic Physics, Stockholm, 1956) for the merging of two oppositely directed magnetic fields in a highly conducting fluid is investigated in a semi-quantitative manner. It is shown that two oppositely directed sunspot fields with scales of 10^4 km could be merged by Sweet's mechanism, if brought firmly together, in about two weeks; their normal interdiffusion time would be of the order of 600 years. It is suggested that Sweet's mechanism may be of considerable astrophysical importance: it gives a means of altering quickly the configuration of magnetic fields in ionized gases, allowing a stable field to go over into an unstable configuration, subsequently converting much of the magnetic energy into kinetic energy of the fluid. (*PA*, 1958, #5130)

124. AN INTRODUCTION TO THE EQUATIONS OF MAGNETOGASDYNAMICS

Steketee, J. A.

University of Toronto, Institute of Aerophysics, Canada

UTIA-REV-9, April 1957 (41 pp.)

A review, in two parts, of magnetohydrodynamics and magnetogasdynamics is presented. In part A, a short discussion of Maxwell's equations in isotropic media at rest is given while the modifications are indicated which have to be made if the media are in motion. In part B, the equations of Maxwell and the hydrodynamic equations are combined to obtain the usual equations of magnetohydrodynamics. The discussion finishes where the ordinary research report begins. (*NSA*, 1959, #5688)

125. AN ENERGY PRINCIPLE OF HYDROMAGNETIC TYPE FROM THE BOLTZMANN EQUATION

Kruskal, M. and Oberman, C.

(Papers presented at the Controlled Thermonuclear Conference held at the Naval Research Laboratory, Washington, D.C., February 3–5, 1958)

Princeton University, N.J., Project Matterhorn

TID-7558

Criteria useful in the discussion of plasma stability in static equilibrium are derived from the Boltzmann equation. (*NSA*, 1959, #5409)

126. ON THE EQUATIONS OF MAGNETOHYDRODYNAMICS

Carini, G.

***Atti della accademia nazionale dei Lincei, Rendiconti, Classe di scienze fisiche, matematiche e naturali*, v. 21, no. 6, pp. 436–441, December 1956 (in Italian)**

The Eulerian hydromagnetic equations for a moving medium are compared with those originally introduced

by Alfvén. The two systems are found to be equivalent only for certain special cases. (See also *PA*, 1957, #8026.) (*PA*, 1958, #4161)

127. ON THE EQUILIBRIUM CONFIGURATIONS OF AN INCOMPRESSIBLE FLUID WITH AXISYMMETRIC MOTIONS AND MAGNETIC FIELDS

Chandrasekhar, S.
***Proceedings of the National Academy of Sciences of the U.S.A.*, v. 44, no. 9, pp. 842–847, September 1958**

Seven integrals of the equations of motion are established, three of which have no analogues in the non-axisymmetric case, and Woltjer's variational method is used to discuss possible equilibrium configurations. The restriction to axisymmetry leads to an enlargement of the class of equilibrium states, but it is concluded that states dependent on the three integrals characteristic of axisymmetry are not likely to have practically realizable counterparts. (*PA*, 1959, #1600)

128. ON THE EQUILIBRIUM CONFIGURATIONS OF PROLATE FLUID SPHEROIDS UNDER THE INFLUENCE OF A UNIFORM EXTERNAL MAGNETIC FIELD

Talwar, S. P.
***Zeitschrift für Astrophysik*, v. 42, no. 1, pp. 42–47, 1957**

The problem of the gravitational stability of non-magnetic prolate fluid spheroidal masses of infinite electrical conductivity is studied under the influence of a uniform external magnetic field. A sequence of prolate spheroids of equilibrium is shown to exist. Further, it is found that the effect of the external magnetic field is to deshape them into thin rod-like shapes, the effect being much more pronounced in smaller and less dense clouds. (*PA*, 1959, #5958)

129. ON THE EQUILIBRIUM OF AN OBLATE LIQUID SPHEROID WITH A MAGNETIC FIELD

Gjellstad, G.
***The Astrophysical Journal*, v. 126, no. 3, pp. 565–572, November 1957**

As an extension of an earlier investigation by Ferraro, the equilibrium of an oblate liquid uniform spheroid with a magnetic field associated with a current proportional to the distance from the axis is being studied. It is shown that such a spheroid cannot be in mechanical equilibrium. For magnetic stars, Ferraro's approximation holds well enough. (*PA*, 1958, #5127)

130. ON THE SOLUTION OF UNSTEADY MOTION PROBLEMS IN MAGNETIC HYDRODYNAMICS

Ladyzhenskaya, O. A. and Solonnikov, V. A.
Steklov Mathematics Institute, Leningrad Branch of the Academy of Sciences, USSR
***Akademii Nauk SSSR, Doklady*, v. 124, pp. 26–28, January 1, 1959 (in Russian)**

An analysis was made of the interaction contact between a magnetic field and the viscous, incompressible flow in it. It is shown that it is possible to determine the values v, p, E, and H of the equation for the above conditions. (*NSA*, 1959, #7895)

131. ON THE STATIONARY ELECTRIC CURRENT DISTRIBUTION IN THE SOLID HELICOID WITH INFINITE LENGTH

Iijima, T.
***Bulletin of the Electrochemical Laboratory*, Tokyo, Japan, v. 21, no. 10, pp. 755–765, October 1957**
(*Physics Abstracts*, 1959 #4600)

132. ON TRAVELING WAVES OF GAS DYNAMIC EQUATIONS

Pogodin, Iu. Ia., Suchov, V. R. and Ianenko, N. N.
***Journal of Applied Mathematics and Mechanics*, v. 22, no. 2, pp. 256–267, 1958 (Translation of *Prikladnaya Matematika i Mekhanika*)**
(*ARS Journal*, Technical Literature Digest, December 1959)

133. ON THE EFFECTIVE FIELD IN A PLASMA

Kadomtsev, B. B.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, pp. 151–157, July 1957 (Translation in *Soviet Physics–JETP*, pp. 117–122, January 1958)**

(Abstracted in *Aero-Space Engineering*, July 1958)

134. ON REFLECTION AND REFRACTION IN MAGNETOHYDRODYNAMICS
Totaro, C.
***Atti dell' Accademia Nazionale dei Lincei*, v. 24, no. 3, pp. 310–316, March 1958 (in Italian)**

The linearized equation $(c^2/\mu\sigma)\,\partial\nabla^2\vec{B}/\partial t + (B_0^2/\mu\rho)\times \partial z^2 = \partial^2\vec{B}/\partial t^2$ for the magnetic induction $\vec{B}$ is established for small disturbances in a liquid of finite conductivity σ in the presence of an external field applied parallel to the z-axis. Fluid velocity and electric intensity and induction are expressed in terms of $\vec{B}$, and the results are applied in a discussion of the reflection and refraction of plane waves at a plane surface of separation of two conducting liquids, the interface being perpendicular to the applied field. (*PA*, 1958, #7200)

135. O NEKOTORYKH TOCHNYKH RESHENIIAKH URAVNENII GAZOVOI DINAMIKI
Grigorian, S.S.
***Akademii Nauk SSSR, Doklady*, August 1, 1958, pp. 606–609**

(Abstracted in *Aero/Space Engineering*, December 1958)

136. ON FORCE-FREE MAGNETIC FIELDS
Chandrasekhar, S. and Kendall, P. C.
***The Astrophysical Journal*, v. 126, no. 2, pp. 457–460, September 1957**

A method of deriving the general solution of the equation curl $H = a\,H$, where a = constant, is given, the solution being found as the sum of a poloidal and a toroidal vector field. Applying this solution to force-free magnetic fields between spherical boundaries, it is found that, as in the axisymmetric case, there is, quite generally, equipartition of energy between poloidal and toroidal components of the field. It is pointed out that any force-free field of this type can decay freely in a fluid without causing any motion of the fluid. (*PA*, 1958, #5109)

137. ON EQUILIBRIUM MAGNETOHYDRODYNAMICAL CONFIGURATIONS
Shafranov, V. D.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 33, no. 3(9), pp. 710–722, 1957 (in Russian)**

The equilibrium conditions for a bounded system of a conducting gas in a magnetic field are investigated. Equilibrium conditions for thin ring with a helical current are obtained: (a) by taking into account gravitational forces, (b) assuming the ring to be surrounded by a gas, and (c) assuming an external magnetic field to be present. A correspondence theorem between equilibrium magnetohydrodynamical systems and hydrodynamical vortices is formulated. On the basis of this theorem the problem of determining the conditions of equilibrium of magnetohydrodynamic configurations reduces to the theory of steady-state motion of an incompressible liquid. General equilibrium conditions for distributed currents are considered on the assumption of axial symmetry. (*PA*, 1958, #1792)

138. ONE-DIMENSIONAL MOTION IN MAGNETOHYDRODYNAMICS
Golitsyn, G. S.
Academy of Sciences of the USSR, Institute of Atmospheric Physics
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, pp. 776–781, 1958 (in Russian)**

The motion of a perfect conducting gas in a magnetic field is investigated. The Riemann invariants for a number of gases are computed and some nonstationary problems are solved. A new method is proposed for determination of the approximate general solution of the magnetohydrodynamic equations. Some types of motion in the presence of shock waves are considered. (*NSA*, 1959, #1656)

139. MOTION OF MAGNETIC LINES OF FORCE
Newcomb, W. A.
***Annals of Physics*, N.Y., v. 3, no. 4, pp. 347–385, April 1958**

To relate to experimental quantities the statement that magnetic lines of force in a conducting fluid move with the fluid one can define (1) a flux-preserving velocity, such that the flux through a closed curve moving with velocity $\vec{v}$ is a constant; or (2) a line preserving velocity, such that a line, moving with velocity $\vec{v}$, which is initially a line of force, remains a line of force in the course of its motion. It is permissible to ascribe a velocity $\vec{v}$ to a line of force if, and only if, $\vec{v}\times(\vec{E}+\vec{v}\times\vec{H})\equiv 0$, and it is always possible to do so. If the drift velocity v_n, i.e., $(\vec{E}\times\vec{H}/\vec{H}^2)$, is not flux-preserving there may be closed curves moving with velocity v_p and a semi-exhaustive enumeration of

such curves is given. A velocity may be line-preserving without being flux preserving but not vice-versa, the necessary and sufficient condition for line preservation being that $\vec{H} \times [\nabla \times (\vec{E} + \vec{v} \times \vec{H})] \equiv 0$. The above considerations are extended to relativistic hydromagnetics. (*PA*, 1958, #5128)

140. MAGNETOHYDRODYNAMICS OF A FINITE ROTATING DISK

Stewartson, K.

***Quarterly Journal of Mechanics and Applied Mathematics*, v. 10, no. 2, pp. 137–147, May 1957**

This report considers the effect of a vertical magnetic field on the motion of a shallow dish of mercury, part of whose base is rotating while the rest is fixed. Both in the absence of the field and when the field is large, there is a steady solution in which the mercury is either uniformly rotating or at rest, there being a thin friction layer separating the two regions. Comparison with experiment suggests that the flow in the absence of the field is unstable but that the motion is stabilized by the field while it is still not large enough to make substantial modifications to the velocity field in the friction layer. (*AMR*, 1958, #898)

141. MAGNETIC FIELDS IN A CONDUCTING FLUID SPHERE WITH VOLUME CURRENTS

Chopra, K. D.

***Journal Geophysical Research*, v. 62, no. 4, pp. 573–579, December 1957**

Force-free and other equilibrium configurations of magnetic fields in a conducting fluid sphere, with volume currents flowing in the interior of the sphere are studied. Assuming the electrical conductivity of the sphere to be infinite, the general conditions governing the force-free and other equilibrium fields are derived, and their solutions obtained. It is found that a force-free field must be a suitable combination of a poloidal and a toroidal part. The magnetic energy is equally divided in its poloidal and toroidal components. The case of finite electrical conductivity is also considered. Here, the possibility of a current distribution is explored such that the corresponding magnetic field does not decay with time.

It is concluded that it is difficult to imagine a poloidal configuration of the magnetic field, whereas a purely toroidal non-decaying magnetic field is certainly possible. (*PA*, 1958, #5131)

142. MACROSCOPIC FOUNDATION OF PLASMA DYNAMICS

Kihara, T.

***Journal of the Physical Society of Japan*, v. 13, no. 5, pp. 473–481, May 1958**

A fluid which comprises several species of charged and neutral particles is treated macroscopically. Basic equations, energy and momentum theorems, and law of similarity are discussed. The condition under which the current equation reduces to the usual form is considered; one-dimensional transverse waves are treated as an example. Quasi-stationary phenomena are examined as a particular case, and it is pointed out that one of the usual basic equations of hydromagnetics, Ohm's law $J = \sigma(E + v \times B)$, should be replaced by rot $(E + v \times B - \sigma^{-1} J) = 0$, v being the velocity of the mean mass flow. An axially symmetric solution is obtained and applied to a self-pinched column, whose stability is explained in an elementary manner. (*PA*, 1958, #8066)

143. INFLUENCE OF FLUID MOTIONS ON THE DECAY OF AN EXTERNAL MAGNETIC FIELD

Spitzer, L., Jr.

***The Astrophysical Journal*, v. 125, no. 2, pp. 525–534, March 1957**

Under conditions of simple symmetry it is shown that fluid motions within a body have a relatively minor effect on the decay rate of an external magnetic field in a vacuum surrounding the body. The magnetic field within the fluid, however, is profoundly influenced by the motions, with the large-scale field much reduced if strong convection currents are present. Two problems are analyzed: an infinite cylinder, in which all quantities are independent of z, and a sphere with axial symmetry. In the first problem the decay rate of the net axial current, I_z, and of the corresponding external B_θ is almost entirely unaffected by the motions, provided that the cylinder radius is much smaller than the radius of the concentric outer cylinder in which the return current is assumed to pass. The equations for the decay of the magnetic vector potential, A_z, are identical with the equations for the change of temperature in a conducting fluid cylinder with the same two-dimensional velocities. In the second problem, in which compressible flow is assumed, the decay rate of the dipole moment, $\mathfrak{M}$, is generally not much affected by axisymmetric fluid motions. In both cases,

however, the large-scale field within the fluid is much reduced in the presence of strong convection, and the external magnetic field is then produced by currents in localized regions, where the convection currents have a reduced effect. In the cylinder the axial current flows in a thin surface layer. In the sphere the currents flow both in a surface layer and in a cylindrical region inclosing the axis of symmetry, where the mean magnetic-field strength is increased by the convection. The increased ohmic dissipation resulting from high currents in localized regions is exactly offset by the work done on the magnetic field by the fluid velocities in these regions. (*PA*, 1958, #2423)

144. HYDROMAGNETIC DISTURBANCES OF LARGE AMPLITUDE IN A PLASMA

Adlam, J. H. and Allen, J. E.
Atomic Energy Research Establishment, Harwell, England
A/Conference 15/ Paper/1

Calculations were made pertaining to the rapid compression of a plasma containing a magnetic field under conditions where collisions can be neglected. (*NSA*, 1959, #6546)

145. FUNDAMENTAL EQUATIONS OF MAGNETOHYDRODYNAMICS AND SOME OF THEIR APPLICATIONS

Carstoiu, J.
***Comptes rendus hebdomadaires des séances de l'académie des sciences*, v. 247, pp. 1716–1718, November 17, 1958 (in French)**

The general expression for the current density in a homogeneous and isotropic medium is considered. Possible applications of the equations obtained are discussed. (*NSA*, 1959, #4018)

146. FUNCTIONAL EQUATIONS OF MAGNETOHYDRODYNAMICS

Kaplan, S. A. and Kolodiy, B. I.
***Dopovidi ta povidomleynna L'vivskiy derzhavna universytet im. I Franka SSSR*, no. 7, pp. 229–230, 1957 (Translated from *Referativnyi Zhurnal, Mekhanika*, SSSR, no. 9, p. 82, 1958)**

By means of Hopf's method a functional equation is obtained, describing the magnetohydrodynamic turbulence in an incompressible liquid:

$$\frac{\partial \Phi}{\partial t} = \int_R y\alpha \left[i \frac{\partial}{\partial x_\beta} \frac{\partial^2 \Phi}{\partial y\alpha(x)\, dx\, \partial y_\beta(x)\, dx} - \frac{i}{4\pi\rho\mu} \frac{\partial}{\partial x_\beta} \frac{\partial z\alpha(x)\, dx \partial z_\beta(x)\, dx}{\partial^2 \Phi} + \frac{i}{8\pi\rho\mu} \frac{\partial}{\partial x_\alpha} \frac{\partial^2 \Phi}{(\partial z_\beta(x)\, dx)^2} + \nu \frac{\partial^2}{\partial x_\gamma^2} \frac{\partial \Phi}{\partial y_\alpha(x)\, dx} + \frac{\partial \Pi}{\partial x_\alpha} dx \right] + \int_R z\alpha \left[i \frac{\partial}{\partial x_\beta} \frac{\partial^2 \Phi}{\partial y_\alpha(x)\, dx\, \partial z_\alpha(x)\, dx} - \frac{\partial}{\partial x_\beta} \frac{\partial^2 \Phi}{\partial y\alpha(x)\, dx\, \partial z_\beta(x)\, dx} + \frac{1}{4\pi\sigma\rho} \frac{\partial^2}{\partial x_\gamma^2} \frac{\partial \Phi}{\partial z_\alpha(x)\, dx} \right] dx$$

This equation is satisfied by a functional which is determined by the equation

$$\Phi(y(x), z(x), t) = \int_\Omega e^{i(y_\alpha v_\alpha + z_\alpha \beta_\alpha)}\, d P^t(\nu, \beta)$$

(*NSA*, 1959, #12,014)

147. MAGNETO-HYDRODYNAMICS NOTE NO. VI

Blank, A. A. and Grad, H.
New York University, Atomic Energy Commission Computing and Applied Mathematics Center
AT(30-1-1480, NYO-6486 MH–VI, July 1, 1958

Some general properties of the equations of fluid magnetics are described. A set of standard nondissipative fluid equations coupled with Maxwell's equations by a Lorentz force term and some form of Ohm's law is adopted. Within this frame there is a considerable amount of flexibility, e.g., in the choice of an equation of state and of a form of Ohm's law and in the decision to include or omit displacement current, electrostatic forces, and electromagnetic momentum. An important criterion in making these decisions is the mathematical tractability of the resultant equations. (*NSA*, 1959, #4812)

148. ELLIPSOIDAL EQUILIBRIUM FIGURE FOR AN ELECTRICALLY CONDUCTING FLUID MASS ROTATING UNIFORMLY IN A MAGNETIC FIELD WHICH VARIES WITH TIME

Agostinelli, C.
Atti dell' accademia nazionale dei Lincei–Rendiconti, Classe di scienze fisiche, matematiche e

naturali, v. 23, no. 6, pp. 409–414, December 1957 (in Italian)

The components of the magnetic field are linear in the x and y coordinates, the coefficients being periodic in time. The fluid is a uniform liquid rotating about the 2-axis. (*PA*, 1958, #3261)

149. AMPERE'S LAW AND THE VECTOR POTENTIAL

Raff, S. J.

***American Journal of Physics*, v. 26, no. 7, pp. 454–460, October 1958**

Some general features of several elementary methods of determining the magnetic field of a current configuration are examined. Ampere's law, the circuital form of Maxwell's equation and a derived relation between the magnetic field and the vector curl of the current, are each applied to the simple problem of computing the magnetic field due to a thin current dipole in a conducting medium. The significance of closed current paths and the conditions under which the return currents in the medium must be included in the computation are discussed for the dc case. The conclusions concerning dc currents are then considered in relation to ac problems and the use of the vector potential in aerial problems. These considerations indicate why only aerial currents enter into the computation of vector potential and the nature of the "thick antenna" problem. (*PA*, 1959, #466)

150. DISPERSION RELATIONS FOR ELECTRONIC PLASMA

Voloshinskii, A. and Kobelev, L.

***Fizika Metallov i Metallovedenie*, v. 6, no. 2, pp. 356–358, 1958 (in Russian)**

The quantization of a plasma theory previously reported (*PA*, 1959, #2047) is adumbrated. The method of Schwinger (*PA*, 1952, #64) is adapted to formulate the quantized collective Green functions, and their evaluation by the method of functional integration is briefly discussed. (*PA*, 1959, #2048)

151. DESCRIPTION OF SYSTEM OF INTERACTING PARTICLES BY MEANS OF GREEN'S FUNCTION

Kobelev, L.

***Fizika Metallov i Metallovedenie*, v. 6, no. 2, pp. 354–356, 1958 (in Russian)**

The concept of a "collective" Green's function is introduced for an assembly of interacting particles, and the formulation of such a function is discussed in terms of the density matrix. Specifically, for an electron gas the Green function is related to the statistical mechanical parameters characterizing the assembly. (*PA*, 1959, #2047)

FLOWS

152. FLOW OF COMPRESSIBLE ELECTRICALLY CONDUCTIVE FLUID
Cabannes, H.
***Comptes rendus hebdomadaires des séances de l'académie des sciences*, v. 245, no. 17, pp. 1379–1382, October 1957 (in French)**

For compressible fluid of infinite electrical conductivity author recalls the equations of magneto-fluid-dynamics and the values of the velocity of the magneto-acoustic waves. He studies particular shock waves and extends formulas which are known in the case of a dielectric fluid. (*AMR*, 1959, #1560)

153. MAGNETODYNAMICS OF PLANE AND AXISYMMETRIC FLOWS OF A GAS WITH INFINITE ELECTRICAL CONDUCTIVITY
Kogan, M. N.
***Prikladnaia Matematika i Mekhanika*, pp. 70–80 January–February 1959 (Translation in *Applied Mathematics and Mechanics*, no. 1, pp. 92–106, 1959)**

Analysis showing that there exists two hyperbolic flow regimes, one of which occurs at subsonic velocities. In this flow regime, shock waves are inclined upstream. For certain values of the ratio between magnetic and hydrodynamic pressures, there exists an elliptic type of flow at supersonic velocities. In this regime weak shock waves do not occur, but strong shock waves are present whose angles of inclination start from the perpendicular. The simple waves for the hyperbolic regimes are constructed and the solutions are presented for the problem of flow around bodies in the linearized and second-order approximations. (*A/SE*, November 1959)

154. AN EXPERIMENT ON AXISYMMETRIC FLOW OF LIQUID SODIUM IN A MAGNETIC FIELD
Lehnert, B.
***Arkiv för Fysik*, vol. 13, no. 10, pp. 109–116, October 1957**

An axisymmetric motion has been generated by a rotating disk in a cylindrical vessel containing 50 liters of liquid sodium and placed in an external magnetic field. Measurements of the internally induced magnetic fields indicate the existence of a toroidal component which circulates around the axis of symmetry and a poloidal component which is restricted to planes through the same axis. The results agree with the elementary theory, as far as orders of magnitude are concerned.

There has been observed neither a formation of instabilities in the twisted field, nor an operation as a self-exciting dynamo; the velocities in the experiment are too small and the degree of asymmetry too low to produce such phenomena. (*AMR*, 1959, #2096)

155. TWO-DIMENSIONAL STOKES FLOW OF AN ELECTRICALLY CONDUCTING FLUID IN A UNIFORM MAGNETIC FIELD
Yosinobu, H. and Kakutani, T.
***Journal of the Physical Society of Japan*, pp. 1433–1444, October 1959**

Analysis of a two-dimensional flow of a viscous, incompressible and electrically conducting fluid past a cylinder in a uniform magnetic field, using Stokes approximation. Detailed calculation is carried out for the flow past a circular cylinder in two cases: (1) in a parallel magnetic field and (2) in a transverse magnetic field. The expansion formulas for the drag per unit span of the cylinder are obtained in terms of the Hartmann Number in each case. (*A/SE*, January 1960)

156. TWO-DIMENSIONAL HYPERSONIC FLOW OF AN IDEAL GAS WITH INFINITE ELECTRIC CONDUCTIVITY PAST A TWO-DIMENSIONAL MAGNETIC DIPOLE
Sakurai, T.
***Journal of the Aero/Space Sciences*, v. 26, p. 841, December 1959**

157. TWO-DIMENSIONAL INCOMPRESSIBLE MAGNETOHYDRODYNAMIC FLOW ACROSS AN ELLIPTICAL SOLENOID
Kemp, N. H. and Petschek, H. E.

AVCO Research Laboratory, Everett, Mass.
RR 26, April 1958 (66 pp.)

(Also in *Journal of Fluid Mechanics*, v. 4, no. 6, pp. 553–584, November 1958)

158. THE USE OF RHEOELECTRIC ANALOGIES IN AERODYNAMICS
Malavard, L. C.
United Nations, North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Paris, AGARDograph-18, August 1956

The rheoelectric analogy method is based on the identity between the equations which govern certain fluid flows and those for the distribution of electric potential in a continuous conducting medium (electric tank, conducting paper, etc.). After a review of the principle of this method, the study describes the equipment and experimental techniques used in model construction, etc. Detailed description is given of the analog methods and set-ups used for the solution of lifting line, propeller, lifting surface, and compressible flow problems.

159. THEORY OF THE FLOW IN THE MAGNETIC ANNULAR SHOCK TUBE
Kemp, N. H. and Petschek, H. E.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
AFOSR TN 59-846, RR 60, July 1959 (35 pp.)

Analysis of the properties of the gas flow in the magnetic annular shock tube. This shock tube uses a magnetic field to drive a shock wave through an annular region, producing a very high temperature plasma. It is shown that this particular configuration allows a fairly precise calculation of the flow parameters. Numerical calculation of the significant flow properties for a complete range of the initial field strength and orientation are made and presented graphically. (*A/SE*, November 1959)

160. THEORY OF THIN AIRFOILS IN FLUIDS OF HIGH ELECTRICAL CONDUCTIVITY
Sears, W. R. and Resler, E. L., Jr.
Cornell University, Graduate School of Aeronautical Engineering, Ithaca, New York
AF 18(600)-1523, AFOSR-TN-58-973, August 1958
(ASTIA AD-205,599)
(Also in *Journal of Fluid Mechanics*, v. 5, pp. 257–273, February 1959)

Steady, plane flow of incompressible fluid past thin cylindrical obstacles is treated, with the undisturbed, uniform magnetic field parallel and perpendicular to the stream. In the first case, flow of an infinitely conducting fluid is shown to be irrotational and current-free except for surface currents at the walls of the obstacles, and for a thin boundary layer for the case of finite but large conductivity. In the second case, for infinite conductivity a system of waves involving currents and vorticity extending out from the body occurs in addition to the irrotational current-free flow, and for finite but large conductivity these waves attenuate exponentially with distance. Forces on sinusoidal walls and on airfoils are calculated.

161. THE QUASI-ONE-DIMENSIONAL FLOW OF AN ELECTRICAL CONDUCTING GAS FOR THE GENERATION OF ELECTRICAL POWER
Sutton, G. W.
General Electric, Missiles and Space Vehicle Department, Evendale, Ohio
G. E. MSVD TIS R 59SD307, Aerophysics Research Memo 25, February 9, 1959 (17 pp.)

Analysis of the inviscid flow equations of a conducting gas, deriving the relation between current, electrical field, and magnetic field for maximum power extraction. For this relationship, the equations are integrated analytically, assuming constant electrical conductivity and an ideal gas for the cases of constant velocity, constant area, constant temperature, constant pressure, and constant density. The constant velocity case is also considered for variable conductivity. The lengths required to extract 10 percent of the initial flow enthalpy are the same magnitude for moderate initial values of Mach Numbers; constant velocity flow yields the minimum length. The constant pressure flow has the least increase in cross-sectional area. (*A/SE*, November 1959)

162. THE MAGNETOHYDRODYNAMIC FLOW PAST A FLAT PLATE
Greenspan, H. P. and Carrier, G. F.
***Journal of Fluid Mechanics*, pp. 77–96, July 1959**

Analysis of the uniform steady flow of an incompressible, viscous, electrically conducting fluid distorted by the presence of a symmetrically oriented semi-infinite flat plate. The ambient magnetic field is coincident with the ambient velocity field. The description of the resulting fields depends on the physical coordinates measured in units of Reynolds Number and on the two parameters ϵ and β. This description of the fields is approximated in three different ways and essentially covers the full range of ϵ and β. In particular, when $\beta \geqq 1$, no steady flow which is uniform at large distances from the plate exists. (*A/SE*, November 1959)

163. THE INTERACTION OF A PLANE STRONG SHOCK WAVE WITH A STEADY MAGNETIC FIELD. APPENDIX A,B—ONE DIMENSIONAL FLOW WITH MOMENTUM LOSS FOR AN IDEAL GAS. APPENDIX C —DESCRIPTION OF SOME INTERACTION EXPERIMENTS

de Leeuw, J. H.
University of Toronto, Canada
UTIA Report 49, March 1958 (80 pp., 13 ref.)

(Abstracted in *Aero-Space Engineering*, August 1958)

164. THE FLOW OF CONDUCTING FLUIDS IN CIRCULAR PIPES UNDER TRANSVERSE MAGNETIC FIELDS

Shercliff, J. A.
***Journal of Fluid Mechanics*, v. 1, no. 6, pp. 644–666, December 1956**

The rate of flow of a liquid can be measured by passing it along a pipe under a transverse magnetic field. The voltage induced between two electrodes situated at the ends of a diameter of the pipe perpendicular to the flow and to the field can then be used to determine the rate of flow. The conductivity of the pipe walls and the form of the velocity profile affect the ratio of induced voltage to flow rate. The present paper comprises analytic study of the steady state of laminar flow in a circular pipe with thin conducting walls under a traverse field and, by means of a Rayleigh approximation, the entry length necessary to achieve it.

Formulation of the equations of performance and the spatial boundary condition is followed by steady-state solution under certain simplifying assumptions to the end that a plot of sensitivity (a measure of flowmeter output) S vs. wall conductivity is afforded; increase of the latter increases the former, due to change in velocity profile. A subsequent analysis of the entry problem for initial uniform velocity yields a plot of sensitivity S and dimensionless pressure gradients $\partial p/\partial z$ as a function (essentially) of a parameter ratio characterizing entry conditions. Experimental work using two Perspex pipes of 0.5 and 0.025-in. internal diameters affords good confirmation of the results of the entry effect investigation. (*AMR*, 1957, #476)

165. THE EFFECTS OF COMBINED ELECTRIC AND MAGNETIC FIELDS OF HYPERSONIC COUETTE FLOW

Bleviss, Z. O.
Douglas Aircraft Co., Santa Monica Division, Santa Monica, Calif., R-SM-23314
October 1958

At hypersonic speeds the air in a high-speed boundary layer becomes an electrical conductor due to the thermal ionization and it can then be made to interact with electric and magnetic fields to alter the skin friction, heat transfer, total drag, etc. Because of the complexity of the problem, no solutions with realistic assumptions have been obtained. In this report a very simple, pure shear, laminar flow (Couette flow) problem is investigated because it contains many important features of boundary layer flow and because it can be solved with a minimum of assumptions about the gas.

166. THE EFFECT OF A MAGNETIC FIELD ON STOKES FLOW IN A CONDUCTING FLUID

Chester, W.
***Journal of Fluid Mechanics*, v. 3, no. 3, pp. 304–308, December 1957**

This paper is an extension of the classical Stokes flow problem defining the drag force experienced by a sphere in a fluid stream. The author treats the case of a magnetic field associated with a conducting fluid. In particular, an incompressible viscous conducting fluid is considered. The flow is assumed to be steady, and the magnetic field at infinity is uniform and in the direction of the stream. The model is restricted to small Reynolds numbers, small magnetic Reynolds numbers, and small Hartmann numbers. Thus, a solution in powers of the Hartmann number can be obtained. The final equation for the drag is then

found to be $D = \{D_s 1 + 3/8M + 7/960M^3 - 43/7680M^3 + 0(M^4)\}$ where D_s is the drag force experienced by a small sphere and M is the Hartmann number in the author's nomenclature.

The paper is concisely presented. It should be very helpful to those interested in further studies of either analytical or experimental nature. (*AMR*, 1959, #472)

167. THE EFFECTS OF COMBINED ELECTRIC AND MAGNETIC FIELDS ON HYPERSONIC COUETTE FLOW

Bleviss, Z. O.
Douglas Aircraft Co., Santa Monica, Calif.
Report SM-23314, October 1958 (47 pp.)

This valuable contribution extends previous work (*Journal of the Aero/Space Sciences*, v. 25, p. 601, 1958). The problem concerns hypersonic ($M = 30$) flow of a thermally ionized gas between parallel planes, one moving, one fixed, bearing rough analogy with the case of a boundary layer between a free stream and a flat plate or cylindrical body. The imposed magnetic field is perpendicular to the planes, and currents circulate perpendicular to the flow and the field. In the previous work the transverse electric field was assumed "shorted out" (as would occur with steady fields and as axisymmetric configuration). This report studies cases ranging from the complete blocking of the total transverse current, so that the fluid polarizes, to cases where the current is reversed by electric fields imposed by electrodes to give a propulsive effect. A nonvanishing electric field means that energy is transferred transversely by the currents.

Several cases are solved, some with the fluid properties assumed constant. This simplification gives qualitatively correct results in most cases. Among the conclusions are the facts that no combination of electric and magnetic fields reduces the heating of the fixed wall, although total drag can be increased much more than heating, particularly for zero electric field. The problem is therefore more relevant to re-entry than glide paths. Prospects for propulsion are poor since skin friction is increased at the same time. (*AMR*, 1959, #4153)

168. SUPERSONIC TWO-DIMENSIONAL MAGNETOHYDRODYNAMIC FLOW

Fishman, F., et al.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
R-39, February 1959

Experimental and theoretical treatment of a two-dimensional supersonic flow problem is reported. In order that the magnetic field be the predominating factor, a loosely wound circular solenoid is used. The e.m.f. induced in the gas flow inside the solenoid is perpendicular to both the flow direction and the magnetic field. If the resulting current is parallel to this e.m.f., the forces on the gas are anti-parallel to the flow and therefore represent drag. Sometimes the Hall effect becomes important and lift as well as drag forces are induced. The various parameters involved in the two-dimensional supersonic flow problem are explained: the study is described, and results are given.

169. SUPERPOSABILITY IN MAGNETOHYDRODYNAMICS

Kapur, J. N.
***Applied Science Research*, A, v. 8, no. 2–3, pp. 198–208, 1959**

The concept of superposing two hydromagnetic flows is defined, and it is shown that force-free fields (Chandrasekhar) and self-superposable fluid flows (Strang) are particular cases of this concept. Chandrasekhar's equations for axially symmetric hydromagnetic flows are extended to viscous fluids. It is found that some important results for non-viscous flows need not hold for viscous fluids.

170. SOME EXACT SOLUTIONS TO THE MAGNETOHYDRODYNAMIC EQUATIONS FOR INCOMPRESSIBLE FLOW

Hains, F. D.
***Journal of the Aero/Space Sciences*, pp. 246–247, April 1959**
(*Pacific Aeronautical Library*, 1959, #33643)

171. SOME BASIC ASPECTS OF MAGNETOHYDRODYNAMIC BOUNDARY-LAYER FLOWS

Hess, R. V.
National Aeronautics and Space Administration, Washington, D.C.
Memo 4-9-59L, April 1959 (42 pp.)
(*ARS Journal*, Technical Literature Digest, December 1959)

172. STATIONARY CONVECTIVE FLOW OF AN ELECTRICALLY CONDUCTING LIQUID BETWEEN PARALLEL PLATES IN A MAGNETIC FIELD

Gershuni, G. Z. and Zhukhovitskii, E. M.

***Soviet Physics—JETP*, v. 7, no. 3, pp. 461–464, September 1958**

(Translation of *Zhurnal Eksperimentalnoi i Fiziki, Akademiia Nauk SSSR*, v. 34, no. 3, pp. 670–674, March 1958, by American Institute of Physics, Inc., N.Y.)

An analysis is presented on the induced velocity, temperature and magnetic field distribution between two vertical plates at different temperatures when an external magnetic field is applied perpendicular to the plate. The fluid is viscous, electrically and thermally conductive. Neglecting displacement currents in Maxwell's field equations and viscous dissipation in the energy equation, the author solves for the free convective velocity temperature and magnetic field between the two plates in terms of the distance between plates, the Grashof number and the Hartmann number. (*AMR*, 1959, #4154)

173. SPACE CHARGE LIMITED CURRENT FLOW FROM A PLANE, PLASMA "CATHODE"

Fried, B. and Heflinger, L.

Space Technology Labs., Inc., Physical Research Lab., Los Angeles, Calif.

R-TR 59–0000–00870, October 26, 1959, AF 04(647)-309

The object of this report is to derive an equation analogous to Langmuir's for the case where kT_e/e is large compared to the potential difference between anode and cathode. Study is made of a simple case–plane, parallel geometry–for which an exact solution can be found.

174. SELECTED TOPICS FROM THE THEORY OF GAS FLOW AT HIGH TEMPERATURES (V): THE APPLICATION OF TRANSFER EQUATIONS TO THE CALCULATION OF DIFFUSION, HEAT CONDUCTION VISCOSITY AND ELECTRIC CONDUCTIVITY, INTRODUCTION AND PART I.

Burgers, J. M.

University of Maryland, Institute for Fluid Dynamics and Applied Mathematics, College Park, TN-BN-124a, May 1958

AF 18(600)-993; AFOSR-TN-58-427

(ASTIA AD-158, 230)

The equations of transfer are deduced from the Maxwell-Boltzmann equation, in the form in which this is known for binary collisions. The results have been given in a form with all terms complete, including those depending upon electric and magnetic forces. Part I of the report brings the deduction of the transfer equations. Part II gives applications to the calculation of the coefficients of diffusion in first and second approximation, including thermal diffusion, of heat conduction, of viscosity, of electric conductivity, and of temperature exchange between the constituents of a gas mixture.

175. RESOLUTION OF AN INITIAL SHEAR-FLOW DISCONTINUITY IN ONE DIMENSIONAL HYDROMAGNETIC FLOW

Bazer, J.

***The Astrophysical Journal*, v. 128, no. 3, pp. 686–712, November 1958**

The problem of the resolution of an initial shear-flow discontinuity in an infinitely conducting, compressible fluid is treated. The discussion applies equally well to a flow which is initially parallel to a perfectly conducting wall. The basis of both probems is that a shear flow is an "inadmissible" hydromagnetic contact discontinuity if a component of the magnetic field normal to the surface of discontinuity is present. The motion which results when a shear-flow discontinuity is present initially is investigated. It is shown that this motion may be described in terms of known solutions of the hydromagnetic shock and continuum equations. The dependence of the final constant state of the medium on the initial state is analyzed by analytical and numerical means. Formulae for various quantities of interest are given for the limiting cases of weak and strong initial shear flows. (*PA*, 1959, #4832)

176. REMARKS ON ROCKET AND AERODYNAMIC APPLICATIONS OF MAGNETOHYDRODYNAMICS CHANNEL FLOW

Wilson, T. A.

Cornell University, Graduate School of Aeronautical Engineering, Ithaca, N.Y.

AFOSR TN 58-1068, December 1958 (55 pp.)

(ASTIA AD-207, 228)

Development of the equations of magnetohydrodynamic flow and application of the results to rocket propulsion with unlimited energy supply. The gravity-

free chemical-fuel rocket equations are analyzed. The maximum payload velocity is obtained by programming the exhaust velocity; this involves storing energy during part of the rocket flight. The conditions are given for maximizing payload energy of a rocket by replacing fuel by nonenergetic, high-density material. A magnetohydrodynamic generator converting the kinetic energy of a gas into electrical energy is described along with a magnetohydrodynamic hypersonic wind tunnel and diffuser. The latter is much less efficient than the geometrical diffusers, but power lost by the fluid in the diffuser may be used in another part of an engine cycle with possible net advantages. (*A/SE*, August 1959)

177. MAGNETO-GASDYNAMIC CHANNEL FLOW
Resler, E. L., Jr., and Sears, W. R.
***Zeitschrift für angewandte Mathematik und Physik*, v. 9b, pp. 509–516, March 25, 1958**
(*ARS Journal*, June 1959)

178. ON SERIES EXPANSIONS IN MAGNETIC REYNOLDS NUMBER
Rossow, V. J.
National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.
TN D-10, August 1959

The method of finding magnetohydrodynamic flow solutions by expansion of the flow parameters in a power series of the magnetic Reynolds number $\mathrm{Re} = \sigma\mu UI$ is discussed. The expansion in positive powers is a straightforward but tedious process. The expansion in negative powers is not so tedious but may not give realistic results for the terms of order higher than the first.

179. O PRIBLIZHENNOM METODE ISSLEDOVANIIA PLOSKIKH VIKHREVYKH TECHENII V MAGNITNOI GIDRODIN-AMIKE
Nochevkina, I. I.
***Akademii Nauk SSSR, Doklady*, pp. 1220–1223, June 21, 1959 (in Russian)**

Development of an approximate method for studying steady two-dimensional vortex flows of an ideal compressible fluid in a magnetic field, perpendicular to the plane (x, y) of the flow. The interaction problem for the magnetic and hydrodynamic phenomena in the medium of infinite conductivity, as well as the determination of basic parameters of the medium, can be reduced to the solution of a system of partial nonlinear differential equations. The method is used to derive a solution for $M = 1.73$ and a satisfactory approximation is obtained for the range $1.56 \leq M \leq 1.9$. The method is applicable to the investigation of subsonic and supersonic nonisentropic flows in the limited Mach number range with a specified form of the equation of state. (*A/SE*, October 1959)

180. ON PITOT PRESSURE IN AN ALMOST FREE MOLECULE FLOW—A PHYSICAL THEORY FOR RAREFIED GAS FLOWS
Liu, U. C.
***Journal of the Aero/Space Sciences*, pp. 779–785, December 1958 (18 ref.)**

(Abstracted in *Aero/Space Engineering*, December 1958.)

181. ON MOTIONS WITH HOMOGENOUS DEFORMATION IN MAGNETO-HYDRODYNAMICS
Kulikovski, A. G.
***Soviet Physics—JETP*, v. 3, no. 3, pp. 507–509, May–June 1958, (*ARS Journal*, October 1959)**

182. ONE-DIMENSIONAL UNSTEADY FLOW OF MAGNETOGASDYNAMICS
Pai, S. I.
Proceedings of the Fifth Midwestern Conference on Fluid Mechanics, University of Michigan, Ann Arbor, April 1957 (pp. 251–261)

Author investigates the characteristics of one-dimensional linear nonsteady perfect gas flow. Three types of characteristics are shown to exist: (1) the flow lines or particle paths; (2) a parabolic constant time characteristic not existing for nondissipative flows; (3) the lines of propagation of small disturbances or impulse paths which provide an impulse velocity equal to the isothermal sound velocity if only viscosity is zero, to the normal sound velocity if viscosity and thermal conductivity are zero, and to a velocity whose square equals the sum of the squares of the sound and Alfvén velocity if the flow is nondissipative. (*AMR*, 1958, #3600)

183. **ON ONE-DIMENSIONAL CHANNEL FLOW IN THE PRESENCE OF A MAGNETIC FIELD**
Bush, W. B.
Space Technology Labs., Inc., Physical Research Lab, Los Angeles, Calif.
AF 04(647)-309, R-TR-59-0000-00660, May 4, 1959

The differential equations for the one-dimensional, varying-area channel flow of a perfect gas in the presence of a magnetic field are formulated under the restriction that the electric field be zero. The integration of the equations is performed for two cases: (1) in which the quantity $0 = [\sigma By^2/p\,(do/dx)]$ is a constant, and (2) in which the velocity is a known function of the distance, the component of the magnetic field normal to the flow is an arbitrary function of the distance and the electrical conductivity is dependent on temperature alone. The solutions are presented in analytical and graphical form.

184. **ON HYPERSONIC BLUNT BODY FLOW WITH A MAGNETIC FIELD**
Kemp, N. H.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
RR 19, February 1958 (11 pp.)
(Abstracted in *Aero/Space Engineering*, September 1958)

185. **ON THE FLOW OF A VISCOUS ELECTRICALLY CONDUCTING FLUID**
Greenspan, H. P.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
AF 49(638)-61, AFOSR TN 59-1221, RR 73, October 1959

This paper considers the magnetohydrodynamic flow of a viscous incompressible fluid of constant properties past a flat plate. The applied magnetic field is parallel to the free stream direction and the plate is at zero angle of attack. A number of explicit solutions of the linearized theory are presented for the flow past a semi-infinite plate which is either sucking or injecting a conducting fluid into the main stream.

186. **O LAVLENII MAGNITNOGO "OTZHATIIA" POTOKA PROVODIASHCHEI SREDY**
Zhigulev, V. N.
***Akademii Nauk SSSR, Doklady*, pp. 521–523, May 21, 1959 (in Russian)**

Study of the flow of conducting gas around bodies with a magnetic field. A method of solution is developed for the case involving the pinch effect for high magnetic Reynolds numbers. The problem of hypersonic flow about a system of parallel linear currents is treated as an illustrative example. (*A/SE*, October 1959)

187. **FLUCTUATING LIFT AND DRAG ACTING ON A CYLINDER IN A FLOW AT SUPERCRITICAL REYNOLDS NUMBERS**
Fung, Y.-C.
Institute of the Aeronautical Sciences Annual Meeting, January 25–27, 1960, New York, N. Y.
Paper 60–6

The fluctuating lift and drag acting on a circular cylinder in a flow of an incompressible fluid at large Reynolds numbers were measured. Data on the root-mean-square values of the lift and drag coefficients, and their power spectra at various Reynolds numbers are presented.

188. **A STUDY OF SIMILARITY TRANSFORMATIONS FOR THE EQUATIONS OF TWO-DIMENSIONAL INCOMPRESSIBLE VISCOUS FLUID FLOW**
Wan, K.-S.
Brooklyn Polytechnic Institute, Aeronautical Engineering and Applied Mechanics Dept., N. Y.
PIBAL R-537, AFOSR-TN-59-1257, December 1959

This investigation is carried out to obtain the possible similarity transformations to a laminar flow equation and the Navier-Stokes equation for two-dimensional unsteady and steady flows in both cartesian and polar coordinates.

189. **ON THE FLOW OF A CONDUCTING FLUID PAST A MAGNETIZED SPHERE**
Lundford, G. S. S., and Murray, J. D.
University of Maryland, Institute on Fluid Mechanics and Applied Mathematics, College Park
TN-BN-169, AFOSR TN 59-424, April 1959 (20 pp.)
(ASTIA AD-214,774)

Study of the first-order effects of the magnetic field and conductivity in the steady flow of an incompressible, inviscid, conducting fluid past a magnetized sphere. This leads to a regular perturbation in β, the ratio of magnetic pressure to the free-stream dynamic pressure. Parabolic wakes of vorticity and magnetic intensity are formed, the former being half the size of the latter. The vorticity,

generated by the non-conservative electromagnetic force is shown to be logarithmically infinite on the sphere. Drag on the sphere derives from two sources, the fluid pressure and the Maxwell stress. The drag coefficient is derived for the dipole case in which there is no contribution from the pressure. (*A/SE*, August 1959)

190. ON FLOW OF ELECTRICALLY CONDUCTING FLUIDS OVER A FLAT PLATE IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD
Rossow, V. J.
National Advisory Committee for Aeronautics, Washington, D.C.
Report 1358, 1958 (20 pp.)
(*Applied Mechanics Reviews*, 1959, #3633)

191. ON THE FLOW OF A CONDUCTING FLUID AROUND A MAGNETIZED BODY
Kulikovski , A. G.
***Doklady Akademii Nauk SSSR* (N. S.) v. 117, no. 2, pp. 199–202, 1957 (in Russian)**
Translation by Morris D. Friedman, Inc., Mass. K-172 (5 pp.)

When a stream in which there is no magnetic field passes over a magnetized body, it cannot penetrate the region occupied by the magnetic field if the electrical conductivity of the field is infinite. In this case, there will be a cavity outside the body and the free streamline will cover both the magnetized body and the cavity. In this paper, the fundamental equations for such a free streamline problem are discussed. Since such a free streamline problem does not give a unique solution, author imposed some additional conditions on the magnetic field in order that the solution of the problem may be uniquely determined. Finally, some simple examples of the free-stream problems such as (1) flow around a plane magnetic dipole perpendicular to the flow, (2) supersonic flow around a wedge along whose surface a current of constant density flows parallel to the edge of the wedge, and (3) supersonic flow around a cone along whose surface flows a current of constant density directed perpendicularly to the cone generators. (*AMR*, 1959, #1563)

192. ON HYPERSONIC STAGNATION-POINT FLOW WITH A MAGNETIC FIELD
Kemp, N. H.
***Journal of the Aeronautical Sciences*, v. 25, no. 6, pp. 405–407, June 1958**

The likely value of magnetic fields in reducing heat-transfer rates at the stagnation point of a body in hypersonic flight is discussed with application to satellite re-entry problems. Main interest is centered on estimating magneto-fluid-dynamic effects in the hypersonic flow adjacent to the stagnation point.

The analysis is made for a blunt body having a spherical nose with a radially directed magnetic field and for small magnetic Reynolds numbers. The assumptions of axial symmetry and the body surface as equipotential or nonconducting allow simplification of the problem. A general solution is not obtained but an approximate series solution is obtained for flow conditions directly ahead of the stagnation point (i.e., for $\theta = 0$).

Results indicate the shock is pushed outward a small amount (detachment still of same order); the velocity gradient is decreased and the heat-transfer rates correspondingly.

A typical example based on the analysis shows small reduction in heat-transfer rates (approximately 5%). Author confirms reviewer's belief that this analysis is valid only immediately adjacent to the stagnation point subject to the assumption made.

Five pertinent references are included. (*AMR*, March 1959)

193. ON FLOW IN DIRECT-CURRENT ELECTROMAGNETIC PUMPS (Paper to be presented at the International Symposium on Magneto-Fluid Dynamics, held at Williamsburg, January 17–23, 1960)
Rossow, V. J.
National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

The direct-current electromagnetic pump, which has an electric and magnetic field impressed across the channel to produce a body force on the fluid in a direction along the channel, has been used to investigate the effect of the ends of the electric and magnetic fields on the flow. Various modifications to the geometry of the magnet and electrodes are tried in order to restore a one-dimensional form to the flow.

194. ON A CLASS OF MAGNETIC LAMINAR BOUNDARY LAYERS
Lykoudis, P. S.
Preprints of Papers–Conference held at Heat Transfer and Fluid Mechanics Institute, University of California, Berkeley, 1958 (Printed and distributed by the Stanford University Press, June 1958, pp. 176–186.)

In the present work the general problem of wedge-type flows was investigated; it was shown that general "similarity" solutions exist for the boundary layer if the intensity of the magnetic field acting perpendicularly to the direction of flow varies according to a power law with respect to the distance from the inward stagnation point. In the case of two-dimensional stagnation flow, similarity solutions were obtained when the magnetic field remains constant. The results of this paper—which apply for any fluid as long as it is electrically conducting (such as molten metals)—were particularly investigated for the important case of hypersonic stagnation flow taking into account also dissociation effects. (*AMR*, 1959, #3101)

195. NOTE ON SOME LIQUID FLOW PROBLEMS WITH ELECTROMAGNETIC INFLUENCES
Crausse, E. and Poirier, Y.
9th International Congress of Applied Mechanics, University of Brussels, Belgium, v. 3, pp. 26–36, 1957 (in French)
(*Applied Mechanic Reviews*, 1959, #474)

196. ONE-DIMENSIONAL FLOW OF AN IONIZED GAS THROUGH A MAGNETIC FIELD
Patrick, R. M. and Brogan, T. R.
***Journal of Fluid Mechanics*, v. 5, no. 2, pp. 289–309, February 1959**

The paper describes two types of experiments on the flow of partially ionized argon through a magnetic field. The ionization is produced by strong shocks in a shock tube. One type of experiment is called the "annular" experiment in which the flow area is essentially constant; the second type of experiment, called the "end" experiment, has a flow area which varies linearly in the flow direction. The end experiment had a more uniform magnetic field and had a longer period of steady flow than the annular experiment.

The theoretical discussion of the experimental results is based on the one-dimensional flow equation of Shapiro and Hawthorne [*Journal of Applied Mechanics*, v. 14, p. 317, 1947]. The magnetic effects through magnetic body forces on supersonic (and subsonic) flow for the two types of experiments are worked out by this theory and reasonably good agreement with the observations is found. It is shown that sufficiently strong magnetic fields produce choking of the flow. Observations of the electric current density for both types of experiments show that the electrical conductivity is less than the scalar value. This reduction is conductivity is ascribed to two effects of which the first is the Hall effect and the second is an ion slip effect, i.e., an effect which is produced by a difference between the ion velocity relative to the magnetic field and the neutral particle velocity relative to the field. (*AMR*, 1959, #6329)

197. NONEQUILIBRIUM FLOW OF AN IDEAL DISSOCIATING GAS
Freeman, N. C.
***Journal of Fluid Mechanics*, pp. 407–425, August 1958**

(Abstracted in *Aero/Space Engineering*, October 1958)

198. NONEQUILIBRIUM FLOW IN GAS DYNAMICS
Li, T. Y.
American Rocket Society, June 8–11, 1959, N.Y.
ARS-2, Paper 852–59, 1959
AF 18(600)-1591, AFOSR-TN-59-389
(ASTIA AD-213,893)

The first part of this paper deals with general concepts of fundamental equations, boundary conditions and chemical relaxation. The second part deals with the steady one-dimensional nozzle flow with nonequilibrium chemical reactions. The third part presents a numerical method whereby the inviscid adiabatic flow of a reacting mixture of perfect gases past a blunt body may be calculated.

199. NESTATSIONARNAIA ZADACHA MAGNITNOI GIDRODINAMIKI DLIA POLUPROSTRANSTVA
Regirer, S. A.
***Akademii Nauk SSSR, Doklady*, pp. 983–986, August 11, 1959 (in Russian)**

Study of problems of unsteady one-dimensional flows of viscous, electrically conducting liquid in a magnetic field. The liquid is assumed to fill the semispace Ω ($y > 0$), flow and force lines of the induced fields are parallel to the X-axis, and the force lines of the constant external field are parallel to the Y-axis. As an illustrative example,

an exact solution is derived for the analogous problem of diffusion in a vortex layer. It is shown that, for $t \to \infty$, the solution for the nonsteady case approaches the corresponding solution of the steady problem. If a constant non-zero value of H is given for $y = 0$ in the initial nonsteady problem, the solution obtained in the boundary at $t \to \infty$ is the same steady solution, but with different conditions at infinity. (*A/SE*, December 1959)

200. MATCHING OF THE VISCID AND INVISCID REGIONS FOR THE STAGNATION MAGNETIC FLOW
Lykoudis, P. S.
***Journal of the Aero/Space Sciences*, v. 26, pp. 315–317, May 1957**
(*Applied Science and Technology Index*, September 1959)

201. LAMINARE GRENZSCHICHTEN IN DER MAGNETOHYDRODYNAMIK
Jungclaus, G.
***DVL Bericht*, no. 85, March 1959 (25 pp.)**
Westdeutscher-Verlag, Kaln und Opladen (in German)

Investigation covering laminar boundary layers in flows of electrically conducting compressible fluids in the presence of a magnetic field. Conditions are studied under which the pressure normal to the boundary layer is constant, leading to the development of a general boundary layer theory. For very strong magnetic fields the solution is particularly simple. Similar solutions are established for the general case of magnetic fields of arbitrary strength. Mercury and liquid sodium can be used for the experimental verification of the obtained results. (*A/SE*, June 1959)

202. MAGNETOHYDRODYNAMIC-HYPERSONIC FLOW PAST A BLUNT BODY
Bush, W. B.
***Journal of the Aero/Space Sciences*, v. 25, pp. 685–690, 728, November 1958 (see also v. 26, pp. 536–537, August 1959)**
(*Applied Science and Technology Index*, December 1959)

203. MAGNETOHYDRODYNAMICS FLOW EXPERIMENTS OF A STEADY STATE NATURE
Blackman, V. H.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 1007-59

This paper describes an attempt to combine the steady-state flow characteristics of a wind tunnel with the high temperature capabilities of a shock tube.

204. MAGNETOHYDRODYNAMIC-HYPERSONIC FLOW IN THE QUASI-NEWTONIAN APPROXIMATION
Meyer, R. X.
Space Technology Laboratories, Inc., Physical Research Lab, Los Angeles, Calif.
AF 04(647)-309, May 21, 1959
(Ramo-Wooldridge Corp., R-TR-59-0000-00690)

The theory of the quasi-Newtonian approximation to magnetohydrodynamic flow is developed. Results are presented, concerning the flow of an ionized gas in the shock layer of a re-entry body. A similarity solution, valid for arbitrarily varying conductivity, is obtained for a circular cone at zero angle of attack.

205. MAGNETOHYDRODYNAMIC FLOW IN A SHOCK TUBE
Mitchner, M.
Lockheed Aircraft, Missile Systems Division, Sunnyvale, Calif.
Tr LMSD-48381, vol. III, p. 1–34, January 1959
(Also in *Physics of Fluids*, pp. 62–71, January–February 1959)

Analysis of the effect of a transverse magnetic field on the motion of a perfectly conducting fluid in a shock tube. A generalized form of the Riemann invariant for the continuous motion of such a fluid is combined with the conservation equations for a magnetohydrodynamic shock to obtain an exact description of the fluid motion in a shock tube in terms of arbitrary initial conditions. The fluids are assumed to have constant specific heat ratios. Qualitatively, the effect of the magnetic field is equivalent to that of pressure, but quantitatively the effect is always greater than merely the hydrodynamic pressure equivalent to the appropriate Maxwell stress. A magnetic field in the high-pressure region alone can produce shocks having Mach numbers for typical laboratory conditions of the order of hundred or more, and is in general agreement with available experimental results. (*A/SE*, April 1959)

206. **MAGNETOHYDRODYNAMIC EFFECTS IN AERODYNAMIC FLOWS**
Sears, W. R.
ARS Journal, p. 397, June 1959

207. **MAGNETO HYDRODYNAMIC DISTORTION OF A MAGNETIC FIELD DUE TO A UNIFORM FLOW**
Falk, D. S.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
RR 29, April 30, 1958 (5 pp.)
(*ARS Journal*, p. 469, June 1959)

208. **MAGNETO-GASDYNAMICS OF HYPERSONIC COUETTE FLOW**
Bleviss, Z. O.
Douglas Aircraft Co., Inc., Santa Monica, Calif.
Report SM-23098, February 1958

(Abstracted in *Aero/Space Engineering*, October 1958)

209. **MAGNETO-GASDYNAMIC FLOW REGIMES (TN)**
Liu, C. S. and Cambel, A. B.
ARS Journal, p. 871, December 1959

210. **MAGNETOHYDRODYNAMIC CHANNEL FLOW OF A PERFECT GAS FOR THE GENERATION OF ELECTRICAL POWER**
Sutton, G. W.
General Electric Company, Missile Space Vehicle Dept., Evendale, Ohio
AF 04(647)-269, R59SD473, December 1959

This report considers the channel flow of an ideal compressible gas which is slightly ionized for the purpose of generating electrical power. The electrical conductivity of the gas is taken as a function of temperature and pressure in accordance with well accepted theories, and the reduction in effective conductivity due to the Hall effect is considered.

211. **LAMINAR STEADY-STATE MAGNETO-HYDRODYNAMIC FLOW IN AN ANNULAR CHANNEL**
Globe, S.
Physics of Fluids, pp. 404–407, July–August 1959

Analysis considering the steady flow of an electrically conducting, incompressible fluid in the annular space between two infinitely long circular cylinders under a radially impressed magnetic field. The general magnetohydrodynamic equations are simplified by the conditions of the problem to three equations in pressure, velocity, and magnetic field. One equation gives the pressure variation in the radial direction; the other two are coupled equations for the velocity and magnetic field, which are functions of the radial variable only and may be solved in closed form. In the limiting case where the radii of the annulus become infinite, but their difference remains finite, the solution converges on the expression for magnetohydrodynamic flow between infinite planes under a transverse magnetic field. (*A/SE*, October 1959)

212. **INCOMPRESSIBLE TWO-DIMENSIONAL STAGNATION POINT FLOW OF AN ELECTRICALLY CONDUCTING VISCOUS FLUID IN THE PRESENCE OF A MAGNETIC FIELD**
Neuringer, J. L. and McIlroy, W.
***Journal of the Aeronautical Sciences*, v. 25, no. 3, pp. 194–198, March 1958**

When a blunt body moves through the atmosphere at high hypersonic speeds there exists a cap of ionized gas between the detached shock and the nose of the body. It was considered possible that, by impressing a magnetic field out of the nose of the body and into the conducting gas, some beneficial effects could be derived from this region. In order to demonstrate this fact theoretically, consideration was given to the well-known problem of the two-dimensional stagnation-point flow on an infinite flat plate, modified in two ways: (1) the fluid was assumed incompressible but conducting, and (2) impressed on the fluid was an external parallel magnetic field normal to the plate. From the resulting analysis of the hydromagnetic interaction, it appears that a considerable reduction in skin friction may be possible with reasonable values of the applied magnetic intensity and electrical conductivity of the fluid.

The reduction in shear stress at the wall is found to be a function of a nondimensional parameter $h^2(0)/\gamma$ defined in the text. (*AMR*, 1959, #470)

213. **MAGNETO-GASDYNAMICS OF HYPERSONIC COUETTE FLOW**
Bleviss, Z. O.
Douglas Aircraft Co., Inc., Santa Monica, Calif.

SM-23098, February 1958 (also in *Journal of the Aero/Space Sciences*, pp. 601–605, October 1958 (18 ref.)

(Abstracted in *Aero/Space Engineering*, October 1958)

214. MAGNETOGASDYNAMICS OF HYPERSONIC COUETTE FLOW

Bleviss, Z. O.
Journal of the Aero/Space Sciences, v. 25, no. 10, pp. 601–615, October 1958

Author investigates the problem of plane Couette flow produced when a viscous and electrically conducting gas contained between two infinitely extended plane walls normal to a uniform external magnetic field is set into motion by the relative movement of walls in their own plane. Assuming thermodynamic equilibrium and resonable variations of electrical conductivity, viscosity, and Prandtl number with temperature, numerical solutions are presented for air for the case of insulated wall and for the case of heat transfer for Mach numbers of 20 and 30. The effects of magnetic field upon velocity, temperature, current density and induced magnetic field distributions and upon skin friction, heat transfer and total drag are shown.

The results show that relatively weak magnetic fields produce large increases in total drag, large reductions in skin friction, and at the same time have little effect on heat transfer. Author shows also that with magnetic field total drag is primarily magnetic drag.

215. HYPERSONIC VISCOUS FLOW PAST A BLUNT BODY WITH AN APPLIED MAGNETIC FIELD

Wu, C.-S.
Princeton University, Dept. of Aeronautical Engineering, N. J.
AFOSR TN 58-1125, Report 443, November 1958 (26 pp.)
(ASTIA AD-207,843)

Analysis showing that local similarity solutions of flow field and temperature distribution are obtainable if both hydromagnetic interaction and viscous effect are taken into account. Various simplifying assumptions are made. The similarity solutions for the two-dimensional problem are presented, and the boundary conditions associated with different physical problems are discussed. Boundary conditions and similarity solutions for the stagnation point flow behind a detached shock wave with spherical shape are investigated. The temperature distribution and the pressure variation in the shock layer near the stagnation point region are studied. (*A/SE*, March 1959)

216. HYPERSONIC GAS DYNAMIC CHARTS FOR EQUILIBRIUM AIR

Feldman, S.
AVCO Manufacturing Corp., AVCO Research Lab., Everett, Mass.
January 1957
Charts

A collection of charts is presented for the equilibrium properties of air in several flow situations of interest in hypersonic flow. The cases considered are: (a) flow over bodies in flight at hypersonic flow; normal and oblique shocks: (b) flow over bodies in shock tubes; this includes moving, standing and reflected normal shocks as well as oblique shocks. A Mollier diagram is also included.

217. HYPERSONIC STAGNATION-POINT FLOW WITH A MAGNETIC FIELD

Kemp, N. H.
Journal of the Aeronautical Sciences, v. 25, pp. 405–407, 1958 (discussion)
Freeman, N. C.
Journal of the Aeronautical Sciences, v. 26, pp. 670–672, 1959 (reply)
(*Applied Scienceand Technology Index*, December 1959)

218. RESOLUTION OF AN INITIAL SHEAR-FLOW DISCONTINUITY IN ONE-DIMENSIONAL HYDROMAGNETIC FLOW

Bazer, J.
The Astrophysical Journal, p. 686, July–November 1958

The problem of the resolution of an initial shear-flow discontinuity in an infinitely conducting, compressible fluid is treated. The discussion applies equally well to a flow which is partially parallel to a perfectly conducting wall. The basis of both problems is that a shear flow is an "inadmissible" hydromagnetic contact discontinuity if a component of the magnetic field normal to the surface of discontinuity is present. The motion which results when a shear flow discontinuity is present initially is investigated. It is shown that this motion may be described in terms of known solutions of the hydromagnetic shock and continuum equations. The dependence of the final constant state of the medium on the initial state is analyzed by

analytical and numerical means. Formulae for various quantities of interest are given for the limiting cases of weak and strong initial shear flows.

219. GAS DYNAMICS OF FREE MOLECULE FLOW

Toomre, A.
Massachusetts Institute of Technology, Fluid Dynamics Research Group, Cambridge
Group Report 58-2, March 1958
AF 49(638)-207, AFOSR-TN-58-787

The influence of a solid object upon the velocity distribution of gas atoms in "free molecule flow" is studied in this report. A concept of *shadow flow* makes it possible to consider two distinct velocity categories, and, in principle, facilitates the calculation of the velocity distribution function at any point in space. The interaction with the surface is considered in detail. The cosine dependence of diffuse reflection, in particular, is shown to be useful.

220. FURTHER ON THE FLOW OF A CONDUCTING FLUID PAST A MAGNETIZED SPHERE

Ludford, G. S. S. and Murray, J. D.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
AFOSR TN-59-648, TN BN-174, June 1959

Analysis considering the steady flow of an incompressible, inviscid, conducting fluid past a sphere of arbitrary conductivity in which there is an arbitrary axially symmetric magnetic distribution. It appears that the singularity in the vorticity can only be absent when the undisturbed magnetic field vanishes at the front stagnation point. Explicit formulas for the drag are given in terms of coefficients defining the distribution; the drag is the same for image distributions with respect to the plane $\theta = \pi/2$. As an example the drag is computed due to an off-center dipole and is found to be larger than for a center dipole of the same moment. (*A/SE*, September 1959)

221. FUNDAMENTAL RESEARCH IN APPLIED MATHEMATICS: THE EFFECT OF AN ALIGNED MAGNETIC FIELD ON OSEEN FLOW OF A CONDUCTING FLUID

Ludford, G. S. S.
University of Maryland, Mathematics Dept., College Park
ITR-43, DA-36-034-ORD-1486, OOR-R-407:52, November 1959

The slow flow of an incompressible, viscous, electrically conducting fluid past a sphere which has the same magnetic permeability as the fluid is considered. The purpose of this paper is to take into account the disturbance of the magnetic field and the inertia of the fluid, by using an Oseen-type approximation in which second-order terms in the disturbance quantities are neglected in the equations of motion.

222. FUNDAMENTAL RESEARCH IN APPLIED MATHEMATICS: FURTHER RESULTS ON THE FLOW OF A CONDUCTING FLUID PAST A MAGNETIZED SPHERE

Ludford, G. S. S.
University of Maryland, Mathematics Dept., College Park
ITR 42, DA 36-034-ORD-1486, OOR-R-407:51, November 1959

The steady flow of an incompressible, inviscid, conducting fluid past a sphere of arbitrary conductivity in which there is an arbitrary axially symmetric magnetic distribution is considered. The vorticity produced by the nonconservative electromagnetic force and the general axially symmetric magnetic distribution are considered in detail. Explicit formulas for the drag are given in terms of coefficients defining the distribution.

223. ACCELERATION OF A PLASMA IN A MAGNETIC FIELD

Gordeev, G. V., and Gubanov, A. I.
***Soviet Physics–Technical Physics*, v. 3, no. 9, pp. 1880–1887, April 1959 (Translation of *Zhurnal Tekhnicheskoi Fiziki SSSR*, v. 28, no. 9, pp. 2046–2054, September 1958 by American Institute of Physics, Inc., N. Y.)**

The acceleration of a plasma between two infinite coaxial cylindrical electrodes due to an external axial magnetic field is considered. Authors compute the stationary plasma flow taking account of friction with the electrode, the dependence of flow velocity on magnetic flux and the radii of the electrodes, and the energy required to maintain the flow. The calculations show that it is possible to achieve supersonic plasma flow velocities with parameters which are realizable in practice. (*AMR*, 1959, #6328)

224. FLOW OF A HYDROMAGNETIC FLUID NEAR AN OSCILLATING FLAT PLATE
Ong, R. S. and Nicholls, J. A.
***Journal of the Aero/Space Sciences*, v. 26, pp. 313–314, May 1959**
(*Applied Science and Technology Index*, September 1959)

225. FLOWS IN PARTLY DISSOCIATED GASES
Metzdorf, H. J.
***Journal of the Aeronautical Sciences*, pp. 200–201, March 1958**
(*Jet Propulsion*, Technical Literature Digest, December 1958)

226. EXPLORATORY EXPERIMENTAL STUDY OF A NEW METHOD OF ENERGY EXCHANGE BETWEEN STEADY FLOWS
Guman, W. J.
Rensselaer Polytechnic Institute, Research Division, Troy, N. Y.
TR AE 5811, May 1958 (56 pp.)
AFOSR TN 59-14
(ASTIA AD-208,595)

Investigation on an energy transfer mode set forth by Foa, concerning radial-flow air-to-air induction by pseudo-blades in free-rotor models. Test results showing the effects of various gasdynamic and geometrical parameters are presented, and results of limited flow visualization studies are discussed. (*A/SE*, May 1959)

227. EXPERIMENTS ON A RADIO FREQUENCY DISCHARGE PLASMA IN SUPERSONIC FLOW
Chuan, R. L. and Smetana, F. O.
Heat Transfer and Fluid Mechanics Institute, Preprints of Papers in Conference held at University of California, Los Angeles, 1959 (Printed and distributed by the Stanford University Press, June 1959, pp. 236–243)

Experiments have been conducted with the view toward developing a radio frequency discharge for use as a heat source in low density, supersonic flows. Early studies had indicated that this heating technique is attended by several little-studied problems, and it was the purpose of these experiments to provide additional data on these phenomena.

Among the problems studied was that of providing a suitable electrode configuration which permits matching of the generator to the load and which provides for minimum stray radiation and high density power input. Also studied was the problem of determining an optimum length of time or distance during which the recombination processes would be sufficiently near completion and for which the physical length would not be unreasonable or the heat transfer to the walls self-defeating.

As a means for permitting the decay processes to reach equilibrium, control of diffusion of free electrons with its subsequent heat transfer to the wall was also studied.

The results of these studies to date and some preliminary interpretations of their significance are given. (*AMR*, 1959, #6325)

228. ENERGY TRANSFER THROUGH A DISSOCIATED DIATOMIC GAS IN COUETTE FLOW
Clarke, J. F.
***Journal of Fluid Mechanics*, pp. 441–465, September 1958 (19 refs.)**

(Abstracted in *Aero/Space Engineering*, December 1958)

229. END EFFECTS IN MAGNETOHYDRODYNAMIC CHANNEL FLOW
Fishman, F.
AVCO Corp., AVCO-Everett Research Lab., Everett, Mass.
Research Note-135, June 1959
AF 04(647)-278, AFBMD-TN-59-5

Some effects associated with the termination of electrodes and magnetic field in an otherwise uniform magnetohydrodynamic channel flow are investigated theoretically. The assumption is made that the magnetic Reynolds number based on the channel height and the interaction parameter are both small, so that the induced magnetic field is negligible and the gas velocity and con-

ductivity are uniform everywhere. Significant exchange of energy may be obtained under these conditions in long channels.

230. ELECTRICAL AND PRESSURE LOSSES IN A MAGNETOHYDRODYNAMIC CHANNEL DUE TO END CURRENT LOOPS

Sutton, G. W.
General Electric Co., Missile and Space Vehicle Dept., Aerosciences Lab., Philadelphia, Pa.
R59SD431, July 22, 1959

The problem of end losses in a magnetohydrodynamic flow has been studied for incompressible inviscid flow in a rectangular channel. Termination of the magnetic field at the ends of the electrodes leads to electrical losses which increase with decreasing aspect ratio of the electrode section of the channel. The losses are also increased with increasing values of the generator coefficient. These electrical losses can be corrected by extensions of the magnetic field beyond the electrode region, but these corrections adversely affect the net pressure change through the device.

231. EFFECT OF TRANSVERSE MAGNETIC FIELD ON THE FLOW DUE TO AN OSCILLATING FLAT PLATE

Kakutani, T.
***Journal of the Physical Society of Japan*, pp. 1504–1509, December 1958**

Determination of the velocity distributions, magnetic field, and related quantities (such as pressure, electric field and current density) for the flow of an incompressible, viscous, and electrically conducting fluid due to an infinite oscillating flat plate in the presence of a transverse magnetic field. General solutions are derived, and some special cases corresponding to limiting values of various parameters are discussed. It is shown that each of the velocity distributions and other related quantities consists of two different oscillations whose decaying factors differ from the corresponding wave numbers. (*A/SE*, April 1959)

232. EFFECTS OF A MAGNETIC FIELD ON THE HYPERVELOCITY FLOW ABOUT A BLUNT BODY

Ziemer, R. W.
Space Technology Labs, Inc., Physics Research Lab., Los Angeles, Calif.
AF 04(647)-165, R-GM-TR-0165-00464, August 27, 1959

An experimental investigation was made of the effect of an applied magnetic field on the bow shock of a blunt body in hypervelocity air flow. Quantitative measurements of the stand-off distance were made in a 3-in. electromagnetic shock tube with free-stream velocities up to 22,000 ft/sec. The test body was a hemispherical cylinder containing a coaxial pulsed magnet coil in the nose which produced field strengths at the stagnation point of up to 40 kilogauss. Application of the magnetic field displaced the bow shock upstream and the stand-off distance increased by a factor of 7.5 for the condition $(\sigma B_0^2 r_b/P_\infty U) = 69$.

233. DYNAMICS OF A DISSOCIATING GAS. I–EQUILIBRIUM FLOW

Lighthill, M. J.
Great Britain Aeronautical Research Council, Engineering Lab., Cambridge, England
R-18,837, R-F.M.2481, R-TP-499, November 14, 1956

Atmospheric dissociation will be appreciable in the neighborhood of projectiles travelling at speeds greater than 2 km/sec. This introductory paper on possible effects of dissociation on the airflow, and hence on the drag, stability and aerodynamic heating of such projectiles, is intended mainly as a source of ideas for later, more comprehensive investigations.

234. DRAG OF A SPHERE MOVING IN A CONDUCTING FLUID IN THE PRESENCE OF A MAGNETIC FIELD

Chopra, K. P. and Singer, S. F.
University of California, Institute on Heat Transfer and Fluid Mechanics, Berkeley
June 1958

Three types of drag associated with magnetohydrodynamic flow are treated theoretically. First, induction drag is considered where the drag is basically due to joule dissipation of energy caused by induced currents either in the medium or the body. The magnetic field may originate within the sphere or in the external medium. The second drag is called coulomb drag and is associated

with momentum transfer between a charged body and electrons and ions moving in the medium. The third type of drag is wave drag associated with energy transfer between highly charged particles moving in a plasma in the presence of an external magnetic field and plasma waves excited by the motion of the body. The plasma waves can propagate through the medium with a frequency below the critical and with phase velocity less than the material velocity of the body.

This paper is recommended to all interested in learning more of the fundamentals of plasma flow in magnetic fields. An understanding of vector notation is required however. (*AMR*, 1959, #2659)

235. COMPRESSIBLE FLAT-PLATE BOUNDARY LAYER FLOW WITH AN APPLIED MAGNETIC FIELD

Bush, W. B.
***Journal of the Aero/Space Sciences*, pp. 49–58**
January 1960 (11 ref.)

USAF-supported development of the boundary-layer equations and solutions for a flat-plate in high speed compressible air flow where equilibrium dissociation and ionization are assumed and where there is an applied magnetic field having its component normal to the plate proportional to $1/\sqrt{x}$. The results show that the skin friction and heat transfer at a given free-stream velocity decrease with increasing magnetic field strength, and the percentage reduction is constant along the length of the plate. They also exhibit the same hysteresis behavior as was first found in the case of magnetoaerodynamic Couette flow; however, for the flat plate the hysteresis effect disappears at a higher Mach number. Furthermore, it was found that the reduction in heat transfer with increasing field strength is opposite in behavior from that for Couette flow (*A/SE*, January 1960)

236. COMPRESSIBLE FLAT PLATE BOUNDARY LAYER FLOW WITH AN APPLIED MAGNETIC FIELD

Bush, W. B.
Space Technology Labs.
Physical Research Lab., Los Angeles, Calif.
AF 04 (647)-165, R-GM-TR-0165-00466
August 19, 1958

The laminar boundary layer equations are formulated and solved for a flat plate in high speed compressible air flow where equilibrium dissociation and ionization are assumed and where there is an applied magnetic field having its component normal to the plate proportional to $1/\sqrt{x}$. The skin friction and heat transfer characteristics are determined for free stream velocities of up to 17,500 meters/sec and magnetic fields of up to about 1 Weber/(meter)^2. The results show that the skin friction and heat transfer at a given free stream velocity decrease with increasing magnetic field strength and the percentage reduction is constant along the length of the plate.

237. CHANNEL TURBULENT FLOW OF AN ELECTRICALLY CONDUCTING FLUID IN THE PRESENCE OF A MAGNETIC FIELD

Lykoudis, P. S.
Purdue University, School of Aeronautical Engineering, Lafayette, Ind.
R-A-59-4, March 1959

Fully establishing turbulent flow in a channel is analyzed for an electrically conducting fluid in the presence of a magnetic field acting perpendicularly to the direction of flow. Velocity profiles, skin friction, correlation coefficients and the distortion of the magnetic field are calculated for different values of the Hartmann number.

238. AXISYMMETRIC STAGNANT FLOW OF A VISCOUS AND ELECTRICALLY CONDUCTING FLUID NEAR THE BLUNT NOSE OF A SPINNING BODY WITH PRESENCE OF MAGNETIC FIELD. I–EXACT SOLUTION OF INCOMPRESSIBLE AND CONSTANT PROPERTIES MODEL

Wu, C.-S. and Hayes, W. D.
Princeton University, Department of Aeronautical Engineering, N. J.
Report 431, April 1958 (46 pp. 11 ref.)
AFOSR TN 58-405,
(ASTIA AD–158,208)

(Abstracted in *Aero/Space Engineering*, December 1958)

239. AXI-SYMMETRIC MAGNETO-GAS DYNAMIC CHANNEL FLOW

Hains, F. D. and Yoler, Y. A.
Boeing Airplane Co.,
Scientific Research Labs., Seattle, Wash.
FSL Report 12, DI-82-0008, August 1959, (57 pp., 15 ref.)

Analysis of the channeling effect of the magnetic field produced by a circular loop of wire on the steady state flow at low magnetic Reynolds numbers of an electrically conducting compressible gas in a circular channel of constant radius, coaxial with the magnetic field. Formal solutions are given for subsonic and supersonic flow, linearized for small values of the magnetic interaction parameter. Shock-tube investigations of wall pressures and wall temperatures are discussed. (*A/SE*, January 1960)

240. A NOTE ON SHOCK FLOW IN A CHANNEL
Gundersen, R.
***Journal of Fluid Mechanics*, pp. 501-504, September 1958**

(Abstracted in *Aero/Space Engineering*, December 1958)

241. A NOTE ON MAGNETOHYDRODYNAMIC HYPERSONIC FLOW PAST A BLUNT BODY
Bush, W. B.
***Journal of the Aero/Space Sciences*, v. 26, p. 536, December 1959**

242. A FURTHER NOTE ON HYPERSONIC STAGNATION POINT FLOW WITH A MAGNETIC FIELD
Kemp, N. H.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-53, April 1959, AFOSR-TN-59-445 (ASTIA AD-214,807)

This report supersedes one entitled "On Hypersonic Blunt-Body Flow With a Magnetic Field" by Nelson H. Kemp, Research Report 19, AVCO Research Laboratory, February 1958, AFOSR TN 58-437, (ASTIA AD-158,242). The purposes of this note are: (1) to give some correct numerical solutions of the inviscid vorticity equation; (2) to present some viscous boundary layer solutions for an axisymmetric stagnation point with magnetic field; (3) to give some of the implications of these solutions for reducing the stagnation point heat transfer rate and shear stress.

243. AN EXPERIMENTAL INVESTIGATION OF THE FLOW PROPERTIES BEHIND STRONG SHOCK WAVES IN NITROGEN
Waldron, H. F.
University of Toronto, Canada
UTIA Report 50, March 1958 (52 pp., 19 ref.)

(Abstracted in *Aero/Space Engineering*, September 1958)

244. FLOW THROUGH A PLANE MAGNETIC NOZZLE
Fried, B. D.
Space Technology Labs. Inc., Physical Research Lab., Los Angeles, Calif.
R-ARL-6-40, November 9, 1956

The problem of the flow of a perfectly conducting fluid through a plane magnetic "nozzle" has been formulated using the one dimensional channel flow approximation for the fluid. The leads to the free boundary problem described by the equation

$$|\nabla\psi|^2 = L^{-2}\chi\,[f(x)] \text{ on } S'$$

While an exact solution has been obtained only for zero flow velocity, the free surface for this case should be nearly the same as for the moving fluid, provided the Mach number is everywhere small compared to 1.

245. ZADACHI OBTEKANIIA V MAGNITNOI GIDRODINAMIKE
Ladyzhenskii, M. D.
***Prikladnaia Matematika i Mekhanika*, pp. 292–298, March–April 1959 (in Russian)**

Study of the flow around a body whose internal magnetic field is generated by an electrically conducting liquid. The solution is derived for large and infinite values of the magnetic Reynolds number. The presence of magnetic forces which act upon the body and are analogous to viscous friction and profile drag is indicated. The particular case studied covers the electric as well as the magnetic internal field, and it is shown that the flow around the body is not affected by the internal electric field sources. (*A/SE*, August 1959)

246. THE STRUCTURE OF HYDROMAGNETIC SHOCK WAVE. I–NONLINEAR HYDROMAGNETIC WAVES IN A COLD PLASMA
Davis, L., Lüst, R., and Schlüter, A.

Zeitschrift für Naturforschung, v. 13 a, no. 11, pp. 916–936, November 1958

The waves in a cold (no thermal motions) quasi-neutral gas consisting of ions and electrons are treated neglecting collisions, but not neglecting the inertial effects associated with the electric current. Provided the particle trajectories do not make loops, the nonlinear equations for infinite plane compressional waves traveling perpendicular to a uniform magnetic field with unchanging form and speed are reduced to a single second-order ordinary differential equation in the field strength (or the particle displacement normal to the direction of propagation) and solved exactly. The solutions can be expressed in terms of elliptic functions. Curves derived by numerical integration give the important properties of the waves. Power series solutions in the amplitude α, are given, the error being of the order of α^4. Both wave trains and solitary waves are found, all solutions being symmetrical about maxima and minima in the field strength. The wavelengths are of the order of the gyro-radius. The velocities range from zero to twice the Alfvén velocity, higher velocities leading to looped trajectories. By reduction to dimensionless form, all waves are included in a two parameter family. The relation of these waves to hydromagnetic shock waves in low density plasmas is considered and it is concluded that the entire shock will have a thickness determined by the product of the mean time between collisions and the gas velocity with respect to the shock front. This region will be occupied by wave trains whose structure is of the order of the gyro-radius. Two analogues of the Rankine–Hugeniot conditions are given, one in which the regions on the two sides of the "shock-front" are occupied by cold plasmas containing different wave trains, the other being the familiar hydromagnetic shock conditions except that only particle motions normal to the magnetic field are considered. In each all conservation laws are satisfied across the "shock-front" but there seems to be no satisfactory mechanism for the processes within the front. (*AMR*, 1959, #2522)

247. THE AMPLIFICATION OF A MAGNETIC FIELD BY A HIGH CURRENT DISCHARGE

Bickerton, R. J.

Proceedings of the Physical Society, London, v. 72, Part 4, pp. 618–624, October 1958

A discharge in a longitudinal magnetic field in which the plasma pressure is balanced by electrodynamic forces is considered. It is shown that the resulting current flow is helical about the axis of the discharge. The direction of the helix is such that the initial longitudinal field is amplified inside the discharge channel. Some experimental evidence supporting the theory is presented. (*PA*, 1959, #1610)

248. STUDY OF THE STABILITY OF RESLER-SEARS FLOWS

Naze, J.

Comptes rendus hebdomadaires des séances de l'académie des sciences, Paris, v. 248, no. 3, pp. 362–365, January 19, 1959 (in French)

One-dimensional motions of a compressible electrically conducting fluid in electric and magnetic fields at right angles to each other and to the motion are considered. The propagation of a discontinuity in acceleration is studied. Of the three stationary flows studied by Resler and Sears (*Zeitschrift für angewandte Mathematik und Physik*, v. 9b, no. 5–6, pp. 509–518, 1958) it is found that the subsonic and supersonic flows are stable with respect to such discontinuities, but the transonic flow is stable only if accelerating. (*PA*, 1959, #4834)

249. STEADY STATE CONVECTIVE MOTION OF AN ELECTRICALLY CONDUCTING LIQUID BETWEEN PARALLEL PLANES IN A MAGNETIC FIELD

Gershuni, G. Z. and Zhukhovitskii, E. M.

Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, v. 34, no. 3, pp. 670–674, 1958 (in Russian)

Steady-state convection of an electrically conducting liquid in the space between parallel planes heated to various temperatures in the presence of a magnetic field is considered. The distribution of velocity, temperature and induced field is determined. The convective heat flow is computed. (*PA*, 1958, #7859)

250. ON CERTAIN QUASI-RECTILINEAR FLOWS OF A FLUID OF FINITE ELECTRICAL CONDUCTIVITY

Naze, J.

Comptes rendus hebdomadaires des séances de l'académie, Paris, v. 248, no. 4, pp. 525–528, January 26, 1959 (in French)

The work of a previous paper (*PA*, 1959, #4834) is generalized to motion in a tube of slowly varying cross section. Heat conduction and viscosity are neglected, but joule heating is included. It is found that variations of cross section do not affect the conclusions previously reached about stability, unless the conductivity is infinite or zero. (*PA*, 1959, #4835)

251. NOTE ON A CLASS OF EXACT SOLUTIONS IN MAGNETO-HYDRODYNAMICS
Lin, C. C.
Archives for Rational Mechanics Analysis,
v. 1, no. 5, pp. 391–395, August 1958

Paper shows how the partial differential equations governing the magnetohydrodynamic flow of an incompressible fluid can be simplified for a particular class of solutions. For these solutions the velocity and magnetic fields, and the pressure gradient are allowed to vary in a general manner with time and one space coordinate, but can only vary in a linear way with the other two space coordinates. A simple nonmagnetic example of this type of motion is steady laminar flow about a rotating disk, where the velocity components take on a variation in the direction normal to the plate, but have only linear variations with radius. Author states that some specific solutions to this set of magnetohydrodynamic equations are being obtained and will be published later. (*AMR*, 1959, #3098)

252. PRELIMINARY RESULTS OF PLASMA HEATING OF HIGH SPEED AIR FLOW
Chuan, R. L.
University of Southern California, Engineering Center, Los Angeles
USCEC Report 56-203, July 31, 1958 (8 pp.)
AFOSR TN 58,650
(ASTIA AD-162,182)

(Astracted in *Aero/Space Engineering*, November 1958)

253. SOME BASIC ASPECTS OF MAGNETO-HYDRODYNAMIC BOUNDARY LAYER FLOWS. APPENDIX–APPLICATION OF THE SIMPLIFIED APPROACH TO A VARIETY OF MAGNETOHYDRODYNAMIC BOUNDARY LAYER FLOWS
Hess, R. V.
National Aeronautics and Space Administration, Washington, D. C.
Memo 4-9-59L, April 1959 (42 pp., 14 ref.)

Presentation of a critical study of existing magneto-hydrodynamic boundary-layer equations for stagnation flow and flat-plate flow. Certain simplifying assumptions are generally introduced into these equations, and the full implication of these has not been brought out properly. It is shown that for the particular law of deformation of the magnetic field postulated, the magnet would have to be situated in the flow away from the body to take up the induced forces resisting the flow. The boundary-layer equation is presented here in a simple form that is especially convenient for physical interpretation. This is done by adapting methods to magnetic forces which in the past have been used for forces due to gravitational or centrifugal action. The simplified approach is used to develop some new solutions of boundary flow, and an asymptotic boundary-layer solution representing a fixed velocity profile and shear is found.

WAVES

254. AN EXPERIMENT ON THE INTERACTION BETWEEN A PLANE SHOCK AND A MAGNETIC FIELD

Dolder, K. and Hide, R.
Nature, v. 181, pp. 1116–1118, April 19, 1958

In order to observe hydromagnetic behavior, experiments were performed on high-speed, high-temperature shock waves, in a shock tube which passes through an intense magnetic field. The simple geometry allows clear pictures to be taken. These are given, with data. (*PA*, 1958, #2902).

255. A NEW APPROACH TO PROBLEMS OF SHOCK DYNAMICS. II—THREE DIMENSIONAL PROBLEMS

Whitham, G. B.
Journal of Fluid Mechanics, pp. 369–386, April 1959

ONR-supported extension of an approximate theory developed previously to three-dimensional problems. The basic equations are derived using the original assumption of a functional relation between the strength of the shock wave at any point and the area of the ray tube. The theory is applied in detail to the diffraction of a plane shock wave by a cone. Then a small perturbation theory is applied to the two typical problems of: (a) diffraction by a slender axisymmetric body of general shape, and (b) the stability of a plane shock. (*A/SE*, 1959)

256. A SIMPLE CONSTRUCTION FOR THE DETERMINATION OF THE MAGNETOHYDRODYNAMIC WAVE SPEED IN A COMPRESSIBLE CONDUCTOR

Rott, N.
Journal of the Aero-Space Sciences, v. 26, pp. 249–250, April 1959
(*ARS Journal*, Technical Literature Digest, December 1959)

257. A STUDY OF THE STRUCTURE OF THE MAGNETOHYDRODYNAMIC SWITCH-ON SHOCK IN STEADY PLANE MOTION

Bleviss, Z. O.
Douglas Aircraft Co., Santa Monica, Calif.
R-SM-23720, October 1959

The structure of the steady magnetohydrodynamic switch-on shock wave is investigated for several order-of-magnitude orderings of the four diffusivities involved in the problem. The various orderings are approximated by allowing one or more of the appropriate diffusivities to approach zero, and approximate solutions that are uniformly valid to order unity are sought. For most of the cases considered, the limiting forms of the integral curves are determined and they are sketched in appropriate three-dimensional phase spaces.

258. HYDROMAGNETIC WAVES IN A HORIZONTALLY STRATIFIED ATMOSPHERE

Ferraro, V. C. A. and Plumpton, C.
The Astrophysical Journal, p. 459, 1958

259. COLLISION FREE MAGNETOHYDRODYNAMIC SHOCK WAVE

Kantrowitz, A., et al.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-63, August 1959

It is assumed that the dissipation in a collision free shock produces a random distribution of magnetohydrodynamic waves. These waves are then treated as the fundamental particles of the plasma. A rough kinetic theory is developed which estimates the heat conduction coefficient due to the waves. Using this heat conduction coefficient, the shock thickness is estimated to be about four times the characteristic ion Larmour radius. This prediction is in rough agreement with experimental results obtained in a Mast device.

260. CYLINDRICAL SHOCK WAVES PRODUCED BY INSTANTANEOUS ENERGY RELEASE IN MAGNETO-GAS DYNAMICS

Pai, S. I.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN BN 120, AFOSR-TN-58-215, February 1958
(ASTIA AD-154,116)

The behavior of a cylindrical shock wave produced by instantaneous energy release along a straight line of infinite extent in a conducting gas subjected to a magnetic field with circular lines of force has been analyzed.

261. DETACHED SHOCK PROBLEM AND RELATED TOPICS
Lieberstein, H. M.
University of Wisconsin, Mathematics Research Center, Madison
TSR-114, DA-11-022-ORD-2059, November 1959

A finite difference method for solving the Cauchy or initial value problem for partial differential equations of elliptic type. Involved in the discussion are certain basic notions related to the (analytic) stability of such problems. Contributions to the theory of hypersonic flow which resulted from application of this numerical method to the inviscid portion of the flow in the nose region of a blunt-nosed body and, also, a successful attack on the related boundary-layer problem using a modified Crank-Nicolson technique are described. It is shown further that the numerical method given is useful in resolving certain scientific questions in connection with engineering design of Pierce-type electron guns.

262. DEVELOPMENT OF HYDROMAGNETIC SHOCKS FROM LARGE AMPLITUDE ALFVEN WAVES
Montgomery, D.
Physical Review Letters, v. 2, no. 2, pp. 36–37, January 15, 1959

A collision-free zero-temperature plasma in which the electron Larmor radius is negligible is considered. Plane-polarized Alfvén waves in this plasma are shown to be described by the same equations as a nonlinear sound wave in an ordinary gas, with $B^2/8\pi$ replacing the pressure, and $\gamma = 2$. The time for an Alfvén wave to develop into a shock is estimated using a result of ordinary shock theory. (*PA*, 1959, #4837)

263. DIFFRACTION OF A PLANE WAVE BY A UNIDIRECTIONALLY CONDUCTING HALF-PLANE
Karp, S. N. and Kline, M.
New York University, Institute of Mathematical Sciences, Electromagnetic Research Division
Research R-EM-108, AF 19(604)1717, AFCRC TN57 974, August 1957
(ASTIA AD-133,799)

Closed form expressions are obtained for the electromagnetic field produced by the diffraction of a plane wave by a semi-infinite unidirectionally conducting screen, and simple far field formulas are given.

264. DIFFRACTION OF A SKEW PLANE ELECTROMAGNETIC WAVE BY AN ABSORBING RIGHT-ANGLED WEDGE
Karal, F. and Karp, S.
New York University, Institute of Mathematical Sciences, Electromagnetic Research Division
Research R-EM-111, AF 19(604)-1717, AFCRC-TN-58-131, February 1958
(ASTIA AD-146,888)

An exact solution of Maxwell's equations is obtained for a plane wave of arbitrary incidences striking a partially absorbing three-dimensional right-angled wedge. In addition to the exact solution, an asymptotic representation for the far field is given.

265. DIFFRACTION OF ELECTROMAGNETIC WAVES USING BRAUNBEK'S APPROXIMATION. II
Frahn, W. E.
Zeitschrift für Physik, v. 156, no. 2, pp. 99–116, 1959
(in German)

The method developed in Part I (*PA*, 1959, #11,290) is applied to the near field of the circular aperture and the circular disk. The field distributions along the central axis and in the plane of the screen are calculated and compared with the results of both the rigorous solution and of Kirchhoff's approximation. The relation of Braunbek's method to other approximation methods for the optical region is discussed. (*PA*, 1959, #12,512)

266. THE DISINTEGRATION OF UNSTABLE SHOCK WAVES IN MAGNETOHYDRODYNAMICS

Lyubarskii, G. and Polovin, R. V.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, pp. 1272–1278, April 1959**

Translation in *Soviet Physics–JETP*, pp. 902–906, October 1959 (15 ref.)

Study considering unstable magnetohydrodynamic shock waves. It is shown that such a wave must necessarily disintegrate into several waves among which there are fast and slow magnetoacoustic shock and similarity waves, Alfvén discontinuities, and a contact discontinuity. It is significant that disintegration of the unstable shock wave is accompanied by an increase in entropy. (*A/SE*, January 1960)

267. PROPAGATION OF PLANE ELECTROMAGNETIC WAVES IN INHOMOGENEOUS MEDIA

Osterberg, H.

***Journal of the Optical Society of America*, v. 48, no. 8, pp. 513–521, August 1958**

The laws of propagation of plane electromagnetic waves along z are derived from Maxwell's equations for inhomogeneous media in which the dielectric constant and the electric conductivity are functions of z and in which the magnetic permeability is constant. The corresponding wave equation is reduced to a Riccati differential equation. A simple method is evolved for treating this Riccati equation without approximation. As a result, it is shown that the laws of propagation depend primarily upon two physical parameters $v(z)$ and $u(z)$ which have the property $v(z) = n$ and $-u(z) = nK$ for homogeneous media, where n is the refractive index. The increase in phase retardation of the wave is always governed by the integral of $v(z)dz$, and $v(z)$ is always the ratio of the phase velocity in vacuum to the phase velocity in the medium. It is shown that sufficiently continuous, single, infinite, inhomogeneous media cannot exhibit reflectance. Fresnel's coefficients of reflectance and transmittance are derived for normal incidence upon a plane boundary between two inhomogeneous media. The theory includes homogeneous media as special cases. (*PA*, 1959, #487)

268. DISSOCIATION AND IONIZATION OF AIR BY A SHOCK WAVE

Thouvenin, J.

***Journal de physique et le Radium*, v. 19, no. 7, pp. 639–648, July 1958 (in French)**

The composition and internal energy of air are computed for a range of temperature from 3500 up to 11500°K and a range of density from 4 up to 12 times normal density. The increase of internal energy of air by a shock wave traveling through it is evaluated in terms of the same parameters. By adjusting both expressions of energy, a relation between the temperature T and the ratio of molecular volumes V_0/V ahead and behind the shock front is obtained. The other physical variables, pressure, front velocity, material velocity, degree of ionization, can be then computed if either of parameters T or V_0/V is known. Conversely, measurement of any one physical variable makes it possible to obtain values of all the others. Calculations show the oxygen to be completely dissociated by strong shock waves (velocities above 7000 m/sec), the nitrogen by a rate of 50 percent higher, and the concentration of free electrons to be over 0.1 percent. (*PA*, 1959, #5846)

269. ELECTROMAGNETIC FIELDS IN CURVED HOLLOW CONDUCTORS

Heyn, E.

***Abhaudlunger der Deutschen Akademie der Wissenshaften, Klasse für Mathematik, Physik und Technik*, no. 4, 1958 (41 pp.)**

Using a perturbation method, the effects of the curvature on the reflection coefficients and on the position of the resonances in high-frequency wavemeters are calculated. (*PA*, 1959, #2517)

270. DYNAMIQUE DES GAZ IONISES: DETERMINATION DES CHOES STATIONNAIRES ATTACHES A LA POINTE D'UN DIEDRE

Cabannes, H.

***La Recherche Aéronautique*, pp. 3–8, July–August 1959 (in French)**

Derivation of equations describing the shock phenomena in an infinitely conducting compressible fluid, and calculation of the stationary shock wave attached to the apex of a dihedral. The shock angle, the pressure, and the temperature over the dihedral are calculated for the zero

electric field. Results show that the presence of a magnetic field increases the wake and reduces the temperature. (*A/SE*, November 1959)

271. ELECTROMAGNETIC PROPAGATION EFFECTS IN FERROMAGNETIC RESONANCE

Seavey, M. and Tannewald, P.
Massachusetts Institute of Technology Lincoln Lab., Cambridge
TR-143, AF 19(122)-458, January 1958

It has been shown that an examination of electromagnetic wave propagation is necessary in the interpretation of ferromagnetic resonance experiments under almost all circumstances of conductivity, geometry and frequency. The electromagnetic effects observed under resonance conditions are examined in detail for insulators, moderate conductors and metals. Modifications of the u'' resonance line which occur when the sample size is of the same magnitude as the skin depth and/or wavelength are derived. Criteria for observing body resonances are given. Detailed calculations and figures are presented which give the power absorbed in semi-infinite and finite thickness slabs of various conductivities.

272. ELECTROMAGNETIC WAVE PROPAGATION IN A MEDIUM WITH VARIABLE DIELECTRIC CONSTANT $1 + Kr^{-1}$

Flammer, C.
Stanford Research Institute, Menlo Park, Calif.
TR 63, AFCRC-TN-57-584
AF 19(604)-1296, Project SRI-1197, January 1958
(ASTIA AD-133,624)

The problem of this report is the calculation of the electromagnetic field in a region with dielectric constant of the form $1 + Kr^{-1}$, when there is a source at an infinitely remote point. It is shown that when a certain simplifying assumption is made, a rather cumbersome closed-form solution is obtained.

273. ELECTRON DYNAMICS

Buneman, O.
Stanford University, Electronic Research Lab., Stanford, Calif.
TR-385-3, AF 33(600)-27784, August 18, 1958

The value of the hydrodynamical approach to electron dynamics is demonstrated and a "unified electron tube theory," covering any system in which an unperturbed electron beam and the electromagnetic fields have cylindrical or planar symmetry, is developed. The hydrodynamical method can also be applied to electron-ion systems with or without a thermal velocity distribution.

274. ELEMENTARY ELECTRIC WAVES. I-A CONTRIBUTION TO THE KINEMATICS OF ELEMENTARY ELECTRIC CHARGES

Bomze, J.
***Sitzungsberichte, Osterreichische Akademie der Wessenschaften Mathematisch–naturwissenschaftliche Klasse.* Abteilung II., v. 166, no. 6–10, pp. 77–109, 1957 (in German)**

The investigation is based on Flamm's line-mechanics of the electromagnetic field. The differential equations for the lines of force associated with a moving charge are derived, and are integrated for the case of motion in a plane. (*PA*, 1959, #1596)

275. EXCITATION OF OSCILLATIONS IN A PLASMA LAYER

Sumi, M.
***Physical Review Letters*, v. 2, no. 2, pp. 37–39, January 15, 1959**

An extension of the author's earlier theory [M. Sumi, *Journal of the Physical Society of Japan* (to be published)] is applied to the possible occurence of standing waves in a uniform plasma layer. The theory is compared with experimental results of Looney and Brown (*PA*, 1954, #4739) Bailey and Emeleus (*PA*, 1956, #6033). (*PA*, 1959, #4747)

276. EXPERIMENTAL DEMONSTRATION OF HYDROMAGNETIC WAVES IN AN IONIZED GAS

Swayer, G. A., Scott, P. L., and Stratton, T. F.
***Physics of Fluids*, v. 2, no. 1, pp. 47–51, January–February 1959**

A regular hydromagnetic oscillation was excited in a linear discharge tube with metal walls. An externally applied axial magnetic field and discharge currents less than 10^4 amperes were essential to the production of the oscillation. Complete spatial current distributions derived from measurements of the radial and time dependence of the three components of magnetic field showed a helical notch (screw thread) of reduced current density which

rotated with uniform angular velocity. The pitch and apparent rotation frequency of the oscillation depended on the gas density, discharge current, and applied axial magnetic field; the right- or left-handedness and rotational sense depended on the relative orientation of the applied axial magnetic field and the self field of the discharge current. The helical regularity could be described as a superposition of hydromagnetic waves traveling in the axial and circumferential directions. (*PA*, 1959, #3655)

277. EXPERIMENTAL GENERATION OF PLASMA ALFVEN WAVES

Allen, T. K., et al.
***Physical Review Letters*, v. 2, no. 9, pp. 383–384, May 1, 1959**

Describes the generation, with controlled condenser discharges, of Alfvén waves in hydrogen at a pressure of 0.1 mm Hg. The propagation of the disturbances in the pre-ionized gas was studied. (*PA*, 1959, #12412)

278. FINAL REPORT ON RESEARCH IN MATHEMATICAL METHODS OF ELECTROMAGNETIC THEORY

New York University, Institute of Mathematical Sciences
DA 49-170-SC-2253, September 1, 1958

This report deals with wave propagation in an inhomogeneous medium surrounding the Earth, statistical theory applicable to wave propagation, asymptotic series solution of Maxwell's equation and nonlinear partial differential equations.

279. FORMATION OF DISCONTINUITIES IN CLASSICAL NONLINEAR ELECTRODYNAMICS

Lutzky, M. and Toll, J.
***The Physical Review*, v. 113, no. 6, pp. 1649–1652, March 15, 1959**

It is shown that discontinuities can develop in the propagation of initially smooth waves governed by a classical nonlinear theory of electrodynamics. The type of theory considered includes as a special case that of Heisenberg and Euler, which describes the modifications that must be made in the Maxwell equations to include the classical limit of the nonlinear vacuum effects of quantum electrodynamics. A particular solution of the equations is constructed by the method of characteristics; this example illustrates how, with the appropriate well-behaved initial conditions, the characteristics can be made to intersect at later times, thus forming discontinuities. The classical approximation fails when the gradient of the field strength becomes large, so that no definite conclusion can be drawn as to the actual physical creation of singularities. (*PA*, 1959, #7205)

280. GAS DYNAMICS RESEARCH WITH THE AIR FORCE INSTITUTE OF TECHNOLOGY SHOCK TUBE

Air Force Dept., Air Force Institute of Technology School of Engineering, Maxwell Airforce Base, Ala.
GAE 56-6/8, August 1956
(ASTIA AD-106,320)

This paper describes the instrumentation, and calibration of the shock tube, as well as indicating the possible usefulness for aerodynamic testing. Two wedge-shaped models of 18 and 60 degree included angle were designed and tested at a Reynolds number of 50,000 and a flow Mach number of about thirty. The photographic results of some of the model tests and numerous calibration curves are included in this report.

281. GENERATION AND THERMALIZATION OF PLASMA WAVES

Stix, T. H.
***Physics of Fluids*, v. 1, no. 4, pp. 308–317, July–August 1958**

Generation of hydromagnetic and ion cyclotron waves by an induction coil is considered for a cylindrical plasma in a uniform confining magnetic field. Resonance widths are calculated and power absorption is calculated and compared to ohmic losses in the induction coil. Rapid thermalization of transverse plasma waves occurs when appreciable numbers of ions stream through the periodic perturbation with velocities such that, in their own rest frames, these ions "feel" the perturbation at their own cyclotron frequency. This effect (cyclotron damping) makes possible an efficient plasma heating scheme for thermonuclear reactors. Radio-frequency power can be

transferred from an induction coil into ion cyclotron waves with an efficiency typically greater than 65%. The wave energy can be quickly transformed into energy of effectively random transverse ion motion by causing the ion cyclotron wave to travel along a magnetic field which decreases slowly with distance. (*PA*, 1959, #359)

282. GROWTH OF ELECTRIC SPACE-CHARGE AND RADIO WAVES IN MOVING ION STREAMS

Piddington, J. H.
***The Philosophical Magazine*, Eighth Series, v. 3, pp. 1241–1255, November 1958**

The following conclusions are reached: (1) In a medium comprising two identical interpenetrating ion streams, four electric space-charge phenomena may occur. The "fast" and "slow" traveling waves are not dealt with; the two effects of interest are nontraveling in a system in which the medium as a whole is at rest. (2) The first is most probably a set of evanescent waves. These have erroneously been interpreted as spatially growing waves and as the basis of the electron-wave and similar amplifiers. (3) The second effect is not an oscillation at all, but an instability in the medium. A single space-charge cloud, however low its density, will, if its linear dimension is large enough, continuously increase in density with time. The mechanism disclosed is quite simple and does not require, as previously suggested, a series of ion clouds (that is, a spatial wave). (4) The effect may occur widely in nature, for example in the solar atmosphere (leading to patchiness and increased radio emission) in interstellar space and in the ionosphere (sporadic E). It also provides a physical picture of the action of the electron-wave tube. (5) An earlier criticism of Bailey's theory of radio waves growing in a medium which drifts along a magnetic field is consistent with special relativity theory. The consistency depends on a suitable definition of "growth," being an increase in amplitude away from the source of the wave. The original definition – increase in amplitude in the direction of travel – indicates growth of virtually all waves to suitably moving observers. (6) The earlier criticism is also confirmed in discussing a previous Laplace transform analysis of the same situation plus a reflecting boundary. A new type of wave (the "transverse space-charge wave") described in this analysis is shown to be spurious and a corresponding theory of solar radio noise untenable. (*PA*, 1959, #7111)

283. HIGH FREQUENCY DIFFRACTION OF ELECTROMAGNETIC WAVES BY A CIRCULAR APERTURE IN AN INFINITE PLANE CONDUCTING SCREEN

Seshadir, S. R. and Wu, T. T.
Harvard University, Cruft Laboratory, Cambridge, Mass.
Scientific R-16, March 10, 1958, AF 19(604)-786, AFCRC-TN-58-138
(ASTIA AD-146,895)

The scattering of plane electromagnetic waves of wave number k by a circular aperture of radius a in an infinitely conducting plane screen of zero thickness and infinite extent is considered. In the limit of large ka and at normal incidence, the ratio of the transmission cross section to the geometrical optical value πa^2, is found up to the order $(ka)^{-5/2}$.

284. HYDROMAGNETIC SHOCKS

Bazer, J. and Ericson, W.
***The Astrophysical Journal*, v. 129, no. 3, pp. 758–785, May 1959**

All physically admissible solutions of the hydromagnetic shock relations for an ideal polytropic gas are exhibited and classified by purely analytical means. The state ahead of the shock (i.e., on the low-density side) is assumed to be known; no restriction is placed on the direction of the magnetic field in front. It is shown, apart from certain "limit" shocks (e.g., pure gas shocks), that the shock velocity and the quantities characterizing the state behind hydromagnetic shocks may be expressed as simple algebraic functions of the discontinuity in the magnetic field across the shock. A natural classification of all hydromagnetic shocks, based on this representation of the state behind the shock, is given. Several useful analytical properties of the various types of hydromagnetic shocks are derived. The results are illustrated graphically for the case of an ideal monatomic gas. The relation between earlier schemes of classification and the present scheme is classified. (*PA*, 1959, #7211)

285. ON THE REFLECTION AND REFRACTION OF HYDROMAGNETIC WAVES AT THE BOUNDARY OF TWO COMPRESSIBLE GASEOUS MEDIA

Simon, R.
***The Astrophysical Journal*, p. 392, 1958**

286. HYDROMAGNETIC WAVES IN IONIZED GAS
Piddington, J. H.
Monthly Notices of the Royal Astronomical Society, London, v. 115, no. 6, pp. 671–683, 1955

A general theory of weak HM waves in anisotropically conducting gas is developed. There are three such HM waves and for each the velocity, absorption, magnetic and electric fields, the Poynting vector and the gas velocity are found. The physical nature of some HM waves is discussed; these include, as limiting cases, radiowaves in ionized gas and *in vacuo*. The effect of Maxwell's displacement current on HM waves is found to be generally small, but it does cause a space-charge electric wave to accompany the HM wave and this could have important consequences. (*PA*, 1959, #3654)

287. INSTABILITY, OR MICROWAVE AMPLIFICATION, IN HIGH-CURRENT DISCHARGE
Buneman, O.
Stanford University, Electronics Laboratory, Calif.
TR-385-4, August 25, 1958, AF 33(600-27784)

The two-stream amplification mechanism is operative between electrons and ions in relative motion. The wavelength of the most rapidly growing fluctuations is the distance traveled in mutual motion during one electron-plasma period. Growth of r-f instabilities takes over from close ion-electron collisions in fully ionized plasmas for damping out any appreciable mutual motion, leading to an effective conductivity $K \varepsilon W_p$, where K is of the order 10-100 for the lighter ions, and W_p is the electron plasma frequency.

288. INTERACTION BETWEEN GRAVITATIONAL CAPILLARY AND MAGNETOHYDRODYNAMIC WAVES
Shirokov, M. F.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, pp. 67–71, July 1957 (Translation in *Soviet Physics–JETP*, pp. 50–54, January 1958)

(Abstracted in *Aero/Space Engineering*, July 1958)

289. INVESTIGATIONS IN ELECTROMAGNETIC THEORY AND MICROWAVE NETWORKS
Oliner, A. A.
Polytechnic Institute of Brooklyn, Electrophysics Group, New York
R-R-560-57, PIB-488 (Final) March 8, 1957
AF 19(604)-890, AFCRC-TR-57-187
(ASTIA AD-117,288)

This final report covers three years of work which has been concerned mainly with propagation and discontinuity effects in non-conventional waveguides. These investigations include the analysis of specific structures such as strip transmission line, trough waveguide, and several types of leaky wave antennas, as well as general studies on leaky waves, periodic structures, and mode theory for anisotropic regions. A second major phase covered is a study in microwave networks which included investigations of network representations of waveguide discontinuities. Miscellaneous topics such as a comprehensive study on H plane slots in rectangular waveguide, and the analysis of scattering of cones have been considered.

290. INVESTIGATION OF SOME IRREGULAR MOTIONS OF A GRAVITATING GAS IN THE PRESENCE OF SHOCK WAVES OF DETONATION, OF THE MAGNETIC FIELD
Yavorskaya Shapshal, I. M.
Avtoref. Diss. Kand Fiz.-Matem. Nauk MGU, Moscow, 1957
Referativnyi Zhurnal Mekhanika, no. 3, 1958, Rev. 3044 (in Russian)
(*Applied Mechanics Reviews*, 1959, #6322)

291. INVESTIGATION OF THE STABILITY OF A GRAVITATING PLASMA IN CROSSED MAGNETIC FIELDS
Meyer, F.
Zeitschrift für Naturforschung, v. 13a, no. 12, pp. 1016–1020, December 1958 (in German)

A plasma with an interior horizontal magnetic field is supported against gravity by a horizontal vacuum field inclined to the interior field at an angle α. This angle can be adjusted so that equilibrium is stable with respect to

disturbances of small wavelength; in particular, the Kruskal-Schwarzschild instability for the case $\alpha = 0$ (*PA*, 1954, #6324) can be removed by a suitable choice of α. Equilibrium is unstable with respect to disturbances of long wavelength. (*PA*, 1959, #4840)

292. KINETIC THEORY OF MAGNETO-HYDRODYNAMIC WAVES
Stepanov, K. N.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 34, no. 5, pp. 1292–1301, 1958 (in Russian)**

Propagation of magnetohydrodynamic waves in an ionized gas is considered, with reference to the thermal movement of the electrons and ions. (*PA*, 1959, #7202)

293. KRASCHETU UDARNYKH VOLN V MAGNITNOI GIDRODINAMIKE
Kiselov, M. I.
***Akademii Nauk SSSR, Doklady*, pp. 524–527, May 21, 1959 (in Russian)**

Presentation of a simplified method for the calculation of shock waves in magnetohydrodynamics. It is shown that the boundary conditions along the front of the perpendicular shock wave lead to cubic equations for computing the parameters of the medium behind the front, but can be reduced to quadratic equations due to the presence of all values belonging to index 1 (index 1 covers all parameters of the medium ahead of the front; index 2 covers the region behind the front) and the availability of a cubic root. The method of calculation is described in detail and the results are analyzed, emphasizing the feasibility of the simplified approach, particularly when additional members characterizing the emission and effect of cosmic rays are introduced. (*A/SE*, October 1959)

294. IONIZATION PHENOMENON OF SHOCK WAVES IN OXYGEN-NITROGEN MIXTURES
Lin, S. C.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
RR 33, June 1958 (23 pp., 15 refs.)

(Abstracted in *Aero/Space Engineering*, November 1958)

295. LONGITUDINAL AND TRANSVERSE WAVES IN THE LORENTZ PLASMA
Rawer, K. and Suchy, K.
***Annalen der Physik*, Leipzig, Folge 7, v. 3, no. 3–4, pp. 155–170, 1959 (in German)**

A discussion of solutions of the third-degree equation for dispersion of electromagnetic waves in an inhomogeneous plasma of temperature T and in a uniform magnetic field, it being assumed that the heavy positively charged particles are immobile. The analysis starts from the Boltzmann equation for the electrons, uses a 3-sheeted Riemann surface, and includes the Appleton-Hartree results as a special case ($T = 0$). (*PA*, 1959, #12515)

296. MAGNETIC FIELD EFFECTS ON BOW SHOCK STAND-OFF DISTANCE
Ziemer, R., et al.
Space Technology Labs., Inc., Physical Research Lab., Los Angeles, Calif.
R-GM-TR-0127-00396, May 16, 1958, AF 04(647)-127

Combined theoretical and experimental investigations have been made to find the effects of applying magnetic fields to the ionized flow about a blunt body of revolution. The effect of the magnetic field on the shock wave stand-off distance is reported in this paper.

297. MAGNETOCONVECTION IN A VISCOUS FLUID OF INFINITE ELECTRICAL CONDUCTIVITY
Malkus, W. V. R.
***The Astrophysical Journal*, p. 259, July 1959**

298. MAGNETOHYDRODYNAMC WAVES
Cole, J. D.
California Institute of Technology, Guggenheim Aeronautical Lab., Pasadena
AF 49(638)-476, AFOSR-TN-59-13, January 1959 (ASTIA AD-208,594)

Shock waves in an infinitely conducting fluid are studied by means of an idealized piston problem. Switch-on waves are shown to be associated with the discharge of a current sheet. The effect of finite conductivity is studied for both ordinary and switch-on waves. It is shown how current sheets are diffused about the wave front. The effects of non-linearity are discussed in a qualitative way.

299. MAGNETOHYDRODYNAMICAL WAVE IN AN ELECTRICALLY CONDUCTING FLUID IN AN UNLIMITED TUBE OF RECTANGULAR CROSS-SECTION
Vacca, M. T.
Atti della academia delle scienze di Torino, Part I, v. 90, no. 2, pp. 633–646, 1955–1956 (in Italian)
(*Physics Abstracts*, 1959, #468)

300. MAGNETOHYDRODYNAMICAL WAVES IN AN IMCOMPRESSIBLE FLUID MASS OF CIRCULAR SHAPE
Agostinelli, C.
9th International Congress of Applied Mechanics, University of Brussels, Belgium, v. 3, pp. 42–45, 1957 (in French)
(*Applied Mechanics Reviews*, 1959, #475)

301. MEASUREMENTS OF THE BOUNDARY LAYER THICKNESS AND RELAXATION OF IONIZATION BEHIND STRONG SHOCK WAVES WITH A NEW CAPACITIVE PROBE
Greenig, H. and Weymann, H. D.
AFOSR TN 58-387, February 1958 (17 pp., 9 fig.)
(ASTIA AD-154,294)

Report deals with the measurements of the thickness of the boundary layer with a capacity probe. This probe inserted flush into the wall of the shock tube and thus avoiding any disturbances in the flow is sensitive to the thickness of the boundary layer when the gas in the undisturbed flow is ionized. The experimental results for argon at Mach numbers between 5 and 10 show the usefulness of the probe for measuring the thickness of the boundary layer, the relaxation time of ionization and the coefficient of diffusion. The experiments were carried out in argon because high Mach numbers could be achieved in argon even with a small shock tube. (*AMR*, 1959, #3105)

302. MICROWAVE PROPAGATION IN HOT MAGNETO-PLASMAS
Drummond, J.
The Physical Review, v. 112, pp. 1460–1464, December 1958
(*ARS Journal*, Technical Literature Digest, 1959)

303. MODEL WAVE FUNCTION STUDY OF NEGATIVE ION PHOTODETACHMENT IN OXYGEN
Brehm, J. J.
Journal of Applied Physics, v. 30, no. 3, pp. 329–333, March 1959

The total cross-section for O^- photodetachment is computed using an analytical model to give agreement with the data obtained by Branscomb, Smith, and Burch. For the calculation of the electric dipole matrix element single-electron wave-functions are constructed for the initial and final states which reflect the short range of the interaction between the neutral atom and the extra electron. These are written in terms of two parameters which are determined in order to fit the experimental data. The bound state parameter β gives an indication of the weak binding of the system and also gives a measure of the "size" of the ion. The continuum state parameter, the s-wave phase shift δ, gives the total cross section for the low energy elastic scattering of electrons by O atoms. (*PA*, 1959, #7122)

304. MOTION OF A CHARGED PARTICLE IN A RECTANGULAR WAVEGUIDE FILLED WITH ANISOTROPIC DIELECTRIC
Bogdankevich, L. S.
Zhurnal Tekhnicheskoi Fiziki, v. 28, no. 7, pp. 1505–1909, 1958 (in Russian)

Evaluation of energy losses of the charged particle for two cases: (a) along the optical axis of the crystal filling the waveguide, (b) in the direction of the parallel and perpendicular axes of the waveguide along which the charged particle is moving. (*PA*, 1959, #3652)

305. THE STRUCTURE OF HYDROMAGNETIC SHOCK WAVES. I. NON-LINEAR HYDROMAGNETIC WAVES IN A COLD PLASMA
Davis, L.,Lüst, R., and Schlüter, A.
Zeitschrift für Naturforchung, v. 13a, no. 11, pp. 916–936, November 1958

The waves in a cold (no thermal motions) quasi-neutral gas consisting of ions and electrons are treated neglecting collisions, but not neglecting the inertial effects associated with the electric current. Provided the particle trajectories do not make loops, the nonlinear equations for

infinite plane compressional waves traveling perpendicular to a uniform magnetic field with unchanging form and speed are reduced to a single second-order ordinary differential equation in the field strength (or the particle displacement normal to the direction of propagation) and solved exactly. The solutions can be expressed in terms of elliptic functions. Curves derived by numerical integration give the important properties of the waves. Power series solutions in the amplitude α, are given, the error being of the order of α^4. Both wave trains and solitary waves are found, all solutions being symmetrical about maxima and minima in the field strength. The wavelengths are of the order of the gyro-radius. The velocities range from zero to twice the Alfvén velocity, higher velocities leading to looped trajectories. By reduction to dimensionless form, all waves are included in a two parameter family. The relation of these waves to hydromagnetic shock waves in low density plasmas is considered and it is concluded that the entire shock will have a thickness determined by the product of the mean time between collisions and the gas velocity with respect to the shock front. This region will be occupied by wave trains whose structure is of the order of the gyro-radius. Two analogues of the Rankine–Hugoniot conditions are given, one in which the regions on the two sides of the "shock-front" are occupied by cold plasmas containing different wave trains, the other being the familiar hydromagnetic shock conditions except that only particle motions normal to the magnetic field are considered. In each all conservation laws are satisfied across the "shock-front" but there seems to be no satisfactory mechanism for the process within the front. (*PA*, 1959, #2522)

306. NON-LINEAR INTERACTIONS OF RADIO WAVES PROPAGATING IN PLASMA

Ginzburg, V. L.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, pp. 1573–1575, December 1958**

307. MECHANISM OF INSTABILITY OF TRANSVERSE PLASMA WAVES

Fried, B. D.

***Physics of Fluids*, v. 2, no. 3, p. 337, May–June, 1959**

Discusses the physical processes responsible for the growth of plasma instability associated with anisotropic electron velocity distributions previously considered by Weibel. (*PA*, 1959, #9728)

308. MILLIMETER WAVES

Kaufman, I. and Wachowski, H.

Ramo-Wooldridge Corp., Electronic Research Lab., Los Angeles, Calif.

Research Program B, January 15, 1958

Progress on the development of generators, amplifiers, methods of detection and measurement, and schemes of utilization of electromagnetic waves of frequency 300 kmc/s or greater is described. Both generation and detection problems are discussed. A separate effort on the theory of plasma oscillations and their relation to ultra-microwave generation is mentioned.

309. NONLINEAR WAVE MOTION. MAGNETOHYDRODYNAMICS NOTE NO. VIII.

Friedricks, K. O. and Kranzer, H.

New York University, N.Y., AEC Computing and Applied Math Center

AT (30-1)-1480, NYO-6486, July 31, 1958

An analysis of the mathemetical structure of the theory governing interaction of magnetic fields with conducting compressible fluids is presented. The basic equations governing magnetohydrodynamics have the same mathematical character as those governing gas dynamics, and the same essential methods may be employed. A typical example is presented to demonstrate that one-dimensional magnetohydrodynamic flow problems can be solved with the aid of shocks and simple waves as in gas dynamics. (*NSA*, 1959, #1460)

310. OBLIQUE SHOCK WAVES IN A PLASMA WITH FINITE CONDUCTIVITY

Kiselev, M. I. and Tseplyaev, V. I.

***Soviet Physics–JETP*, v. 7, no. 6, pp. 1104–1106, December 1958 (Translation of *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 34, no. 6, pp. 1605–1607, June 1958 by American Institute of Physics, Inc., N. Y.)**

The structure of an oblique shock wave in a plasma of finite and isotropic conductivity is considered. Viscosity and thermal conductivity are neglected. The conditions of applicability of the approximation are obtained. An estimate of the thickness of the wave is given. The limiting angle for the propagation of an oblique shock wave is obtained in a plasma of infinite conductivity. (*AMR*, 1959, #4726)

311. OBSERVATIONS OF THE CYLINDRICAL WAVE OF MAGNETO-HYDRODYNAMICS
Carini, G.
***Atti della academia nazionale dei Lincei. Rendiconti, Classe di scienze fisiche, matematiche naturali*, v. 22, pp. 482–488, April 1957 (in Italian)**

It is shown how to utilize the Euler-Minkowski system for the study of the cylindrical waves of magnetohydrodynamics. (*NSA*, 1959, #8182)

312. WATER RIPPLE ANALOGUE OF ELECTROMAGNETIC WAVE PROPAGATION
Walbridge, N. and Woodward, L.
University of Vermont, Physics Dept.,Burlington
TR-3, September 1957, Nonr-597-(01)

In this, the final report under the present contract, are included the simulation of the index of refraction with several applications, the simulation of the Luneberg lens with modifications and several experiments regarding the fundamental nature of wave motion.

313. ON ACOUSTIC ELECTRICAL PHENOMENA IN A DEGENERATE ELECTRON ION PLASMA
Zvryanov, P. and Talutz, G.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki
v. 36, no. 1, pp. 145–148, 1959 (in Russian)

Electrical phenomena appearing in an electron–ion plasma in which acoustic waves are traveling are considered. The space attenuation coefficient (absorption coefficient) of the waves is computed. (*PA*, 1959, #12413)

314. ONE-DIMENSIONAL TREATMENT OF WEAK DISTURBANCES OF A SHOCK WAVE
Powell, A.
Great Britain, ARC CP 441, 1959 (12 pp.)
(British Information Services, N. Y.)

This study covers the case of a shock wave which enters a region of fluid initially at rest and whose motion is disturbed by interaction with sound waves or temperature fluctuations. The resultant sound waves and temperature changes behind the shock are discussed. An outline of a corrected version of an earlier treatment which considered an initially stationary shock wave is included. Numerical values of the interaction coefficients up to $M_1 = 5$ are given. (*A/SE*, January 1960)

315. ON SIMPLE WAVES IN PERFECT AND DISSOCIATING GASES: THEORY AND APPLICATIONS
Kennet, Haim
Massachusetts Institute of Technology,
Fluid Dynamics Research Group, Cambridge
GR-58.1, February 1958
AF 18(600)-961, AFOSR-TN-58-302

A theoretical method is developed for estimating aerodynamic loads on oscillating airfoils in dissociating flow, when the flow is in dissociative equilibrium. The case of hypersonic flow with real gas effects negligible is considered. An extreme case in which real gas effects are not negligible is also investigated.

316. ON THE DIFFRACTION OF ELECTROMAGNETIC PULSES BY CURVED CONDUCTING SURFACES
Wait, J. and Conda, A.
***Canadian Journal of Physics*,**
v. 37, no. 12, p. 1384, December 1959

Starting with the known steady-state solutions for diffraction by a perfectly conducting convex surface, the corresponding transient responses are derived using Fourier–Laplace inversion. Explicit results are given for an incident wave which varies with time as a step function.

317. ON THE DIFFRACTION OF A FINITE BEAM OF ELECTROMAGNETIC WAVES BY A CYLINDRICAL OBSTACLE
Burshtein, E. L. and Solov'ev, L. S.
***Akademii Nauk SSSR, Doklady*, v. 109, pp. 473–476, 1956 (Translation by Morris D. Friedman)**
AF 19(122)-458
(ASTIA AD-110, 285)

318. ON THE DISINTEGRATION OF UNSTABLE SHOCK WAVES IN MAGNETOHYDRODYNAMICS

Lyubarskii, G. A. and Polovin, R. V.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 36, pp. 1272–1278, April 1959 (in Russian)**

The fate of an unstable magnetohydrodynamic shock wave is considered, and it is shown that such a wave must necessarily disintegrate into several waves among which there are fast and slow magnetoacoustic shock and similarity waves, Alfvén discontinuities, and a contact discontinuity. It is significant that disintegration of an unstable shock wave is accompanied by an increase of the entropy. Disintegration of a stable shock wave is impossible. (*NSA*, 1959, #14687)

319. ON THE EFFECT OF ATTENUATION ON GAS DYNAMIC MEASUREMENTS MADE IN SHOCK TUBES

Rose, P. and Nelson, W.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-24, April 1958, AF 04(645)-18

The attenuation of the shock strength of strong shock waves produced in air in high pressure shock tubes is considered. The effects of the non-ideal behavior of air at the high temperatures make an analytical treatment extremely tedious and difficult. Consequently an experimental approach has been pursued. Data on the attenuation experienced in several sizes of shock tubes over a large range of conditions are presented.

320. ON THE FORMATION OF MAGNETOHYDRODYNAMIC SHOCK WAVES

Segre, S.
***Il Nuovo Cimento*, v. 9, no. 6, pp. 1054–1057, September 16, 1958**

A solution of the time-dependent nonlinear equations of magnetohydrodynamics for the propagation of plane (finite) waves is discussed, for a simple case in which there is a strong analogy with hydrodynamics. (*PA*, 1959, #2520)

321. ON THE INTERACTION BETWEEN GRAVITATIONAL CAPILLARY AND MAGNETOHYDRODYNAMICAL WAVES

Shirokov, M.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 33, no. 1 (7), pp. 67–71, 1957 (in Russian)**

The uniqueness theorem for solutions of the hydrodynamical equations for an incompressible strongly conducting ideal liquid is proved. Walen's exact solution for the case when gravitational and capillary forces act on the liquid is shown to be valid. Relations for the conditions of stability, penetration depth, etc., are derived for potential and vortex harmonic waves. In the case of potential motion of the liquid the current density in the surface layer is found to be exactly zero. (*PA*, 1958, #3264)

322. ON THE INTERACTION BETWEEN SMALL PERTURBATIONS AND THE DISCONTINUITIES IN MAGNETOHYDRODYNAMICS AND THE STABILITY OF SHOCK WAVES

Kontorvich, V. M.
Institute of Radiophysics and Electronics, Academy of Sciences, Ukrainian SSR
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, pp. 1216–1625, 1958, November (in Russian)**

A simple geometrical method is presented for the construction of waves diverging (reflected and refracted) from a discontinuity surface and produced by the incidence of a plane monochromatic wave on a plane stationary discontinuity surface in a medium describable by equations of magnetohydrodynamics. The case of a shock wave is considered. The stability of shock waves with respect to inclined incident perturbations is investigated on basis of the results obtained. Variation of the frequency as a result of interaction of small perturbations with shock waves is considered. (*NSA*, 1959, #4899)

323. ON THE MECHANISM OF THERMAL IONIZATION BEHIND STRONG SHOCK WAVES

Weymann, H. D.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN BN-144, July 1958, AFOSR TN 58-788 (ASTIA AD-23, 113)
(*ARS Journal*, Technical Literature Digest, June 1959)

324. ON THE MOTION OF THIN AIRFOILS IN FLUIDS OF LARGE BUT FINITE ELECTRICAL CONDUCTIVITY

McCune, J. E.
Cornell University Graduate School, Ithaca, N. Y.
Aeronautical Engineering Report, January 1959
AFOSR TN 59-456
(ASTIA AD-215,030)

Description of a two-dimensional, small-perturbation theory for the steady motion of thin lifting airfoils in an incompressible conducting fluid, with the uniform, applied magnetic field perpendicular to the undisturbed uniform flow field. The conductivity of the fluid is assumed to be such that the magnetic Reynolds number of the flow is large but finite.

Within this assumption, a theory based on superposition of sinusoidal modes is constructed and applied to some simple thin airfoil problems. It is shown that with this particular field geometry the Alfvén wave mechanism is important in making possible very deep penetration into the flow field of currents and their associated vorticity. It is also shown that the current penetration for an airfoil is much larger than for a wavy wall of wavelength equal to the airfoil chord. (*A/SE*, December 1959)

325. ON THE PROBLEM OF THE ABSORPTION OF ELECTROMAGNETIC WAVES WITHIN THE RESONANCE RANGES OF AN INHOMOGENEOUS PLASMA

Denisov, N. G.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki,
v. 34, no. 2, pp. 528–529, 1958 (in Russian)
English Summary PB 141052T-1 Obtainable from Office of Technical Services, U. S. Dept of Commerce, Washington, D.C., U.S.A.

The propagation of electromagnetic waves in a plasma can be described in terms of a complex refractive index. Earlier work is surveyed and the complete solution is obtained for the case of a weak inhomogeneous plasma. (*PA*, 1959, #9733)

326. ON THE PROPAGATION OF TRANSVERSE ELECTROMAGNETIC WAVES IN A PLASMA IN A MAGNETIC FIELD

Holter, Ø.
University of Oslo, Institute of Astrophysics, Norway
Scientific Report 1, 1959, AF 61(052)49

327. ON THE THEORY OF EXCITATION OF HYDROMAGNETIC WAVES

Akhiezer, A. and Sitenko, A.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki,
v. 35, no. 1(7), pp. 116–120, 1958 (in Russian)

Excitation of hydromagnetic and magnetoacoustic waves by external currents is investigated. Damping of the waves due to the conductivity and viscosity of the medium is taken into account. Excitation by currents is compared with excitation by mechanical means with respect to intensity. (*PA*, 1959, #1608)

328. ON WAVE PROPAGATION IN A PLASMA CABLE WITH EXTERNAL MAGNETIC FIELD

Bittner, G.
Zeitschrift für angewandte Physik,
v. 10, no. 3, pp. 117–122, March 1958 (in German)

An experimental study of wave propagation (attenuation etc.) for frequencies varying from 100–910 Mc. The effects of discharge current (low pressure Hg etc.) and external field etc. on the attenuation were studied. The discharge tubes were ~50–60 cm long and some few cm in diameter. (*PA*, 1959, #5839)

329. PERMANENT STRUCTURE OF SHOCK WAVES WITH JOULE DISSIPATION

Belokon, V. A.
Institute of Physical Chemistry, Academy of Sciences, USSR
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki,
v. 36, pp. 1316–1317, April 1959 (in Russian)

The Raman and isoentropic break of parameters of flow inside a wave of arbitrary amplitude is postulated as analogous to an isothermal discontinuity in a pure heat-conducting gas. (*NSA*, 1959, #14,691)

330. PROPAGATION OF ELECTROMAGNETIC WAVES IN A MULTISTREAM MEDIUM AT GYROMAGNETIC RESONANCE

Neufeld, J.
***The Physical Review* (Second Series)**
v. 116, no. 1, p. 19, October 1, 1959

331. ON THE PROPAGATION OF LONG ELECTRIC WAVES IN A MAGNETIZED PLASMA AND THEIR TRANSMISSION THROUGH PLASMA LAYERS

Schumann, W. O.

***Zeitschrift für angewandte Physik*, v. 10, no. 9, pp. 428-433, September 1958 (in German)**

The propagation of plane electromagnetic waves of small frequency ω is considered when allowance is made for collision damping. For sufficiently small ω, the plasma behaves as a conductor for waves propagated perpendicular to the magnetic field, and also for propagation in the direction of the field in the case of small electron cyclotron frequencies Ω. For large Ω, the propagation in the direction of the field of the two wave types is considered. Reflection and transmission at an air–plasma interface are discussed, and also transmission through a plasma strip of finite thickness. (*PA*, 1959, #2544)

332. RADIATION FROM MODULATED SURFACE-WAVE STRUCTURES

Pease, R. L.
Hughes Aircraft Co., Research Labs., Culver City, Calif.

Scientific R-14, November 1956
AF 19(604)-1317, AFCRC-TN-57-384
(ASTIA AD-117,089)

It is shown that by using a modulated surface-wave structure whose characteristics vary periodically along the direction of propagation, a tilted beam may be obtained without resorting to the use of a finite ground plane. Approximate expressions are derived for the electromagnetic fields in a surface wave which propagates along a typical modulated structures—a rectangular slab of uniform thickness, mounted on a perfectly conducting surface, whose dielectric constant and/or permeability vary slowly in a sinusoidal manner along the direction of propagation. Radiation patterns are computed.

333. THE WAVE MOTIONS OF SMALL AMPLITUDE IN RADIATION-ELECTRO-MAGNETO-GAS DYNAMICS

Pai, S. I. and Speth, A. I.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park

TN BN-180, July 1959
AFOSR TN 59-879

Study of the fundamental equations of radiation electromagneto-gasdynamics. These equations are linearized under the condition that there exists an externally applied uniform magnetic field. Wave motions of infinitesimal amplitude, which may be divided into a transverse wave and a longitudinal wave, are analyzed. Radiation phenomena exert influence only on the longitudinal wave, while the transverse wave is independent of the radiation field. The radiation effect is characterized by introducing a radiation parameter which is the ratio of radiation pressure to the gasdynamic pressure. For an ideal plasma, it may be expressed in terms of an effective radiation sound speed. (*A/SE*, November 1959)

334. RELATED EXPERIMENTS WITH SOUND WAVES AND ELECTROMAGNETIC WAVES

Kock, W. E.
Bendix Aviation Corp., Mishawaka, Ind., Research Laboratories Division (Letter dated March 13, 1959)

Various analog situations in acoustics and electromagnetic waves are described. Certain higher order modes of airborne sound waves in tubes possess a transverse or polarized nature, and electromagnetic properties such as cut-off effects, polarization rotation, and circular polarization can be shown for these sound waves. Externally guided sound waves, similar to radio waves guided by a dielectric rod, are also discussed, as are superdirective acoustic and electromagnetic arrays, space-frequency equivalence in arrays, and experiments in wave diffraction.

335. SHOCK WAVES IN A CONDUCTING ULTRARELATIVISTIC GAS

Stanyukovich, K. P.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, No. 2 (8), pp. 520–521, August 1958 (in Russian) (English translation in *Soviet Physics–JETP*, v. 35 (8) no. 2, pp. 359–360, February 1959)**

Pressure p, density ρ, specific volume V and entropy σ are assumed to be related by the equations $p = (k-1)\rho c^2$, $\rho V^k = \sigma^k$, and velocity is taken perpendicular to magnetic intensity. Conservation laws at a plane shock front are written down and various conditions for no shock wave are noted. (*PA*, 1959, #11937)

336. SHOCK WAVE PROPAGATON IN AN INFINITELY ELECTRICALLY CONDUCTIVE GAS WITH TRANSVERSE MAGNETIC FIELD AND GRAVITATION
Pai, S. I.
Zeitschrift für angewandte Mathematik und Mechanik, v. 39, no. 1–2, pp. 40–49, January–February 1959

337. SHOCK WAVES REFLECTED BY MAGNETIC FIELDS
Atkinson, W. R., Holden, W. R., and Fowler, R. G.
Journal of Applied Physics, v. 30, no. 6, pp. 801–802, June 1959

Fast moving plasmas encountering transverse magnetic fields of order 10^4 gauss are decelerated so rapidly as to produce reflected shock waves. Observations in hydrogen at gas pressures of 1 to about 10 mm Hg are analyzed. There are critical conditions of magnetic field for the onset of the reflection. The velocities of the advancing and reflected waves are recorded as a function of pressure and field. (*PA*, 1959, #8257)

338. SHOCK WAVE STUDIES OF TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES
Lin, S. C.
American Rocket Society, New York
Paper 477–57, August 1957

The possibility of utilizing the shock tube as a tool for obtaining transport properties is demonstrated through a brief summary of some transport information for high temperature air which has already been obtained from recent shock tube studies.

339. SIMPLE VORTICITY LAWS IN MAGNETOHYDRODYNAMICS
Wu, C.-S.
Princeton University, Aeronautical Engineering Dept., N. J.
R-445, November 1958
AF 49(638)-465, AFOSR-TN-58-1044
(ASTIA AD-306, 756)

Some simple vorticity laws in magnetohydrodynamics have been derived. The discussions include the generalized Crocco's vorticity law and Lighthill's vorticity expression behind three-dimensional shock wave. Finally, a generalization of Hayes dynamic derivation of vorticity jump across a gas dynamic discontinuity is also obtained.

340. SIMPLE WAVES IN MAGNETIC HYDRODYNAMICS
Akhiezer, A. I., Lyubarskii, G. Y., and Polovin, R. V.
Kharkov State University, Ukraine
Fiziologicheskii Zhurnal SSSR, v. 3, pp. 433–438, 1958 (in Ukrainian)

The connection between simple and linearized plane waves is investigated. All simple waves in magnetic hydrodynamics are found. It is shown that in magneto-hydrodynamics, as in ordinary hydrodynamics, the region of constant flow may border only on a simple wave in the absence of shock waves. (*NSA*, 1959, #4051)

341. SLOW WAVE PROPAGATION IN PLASMA WAVEGUIDES
Trivelpiece, A. W.
California Institute of Technology, Pasadena
Thesis, 1958

Space charge wave modes of propagation usually associated with drifting of an electron beam are shown to be capable of propagating and carrying energy in stationary electron beams or plasmas of finite transverse cross section. Properties of the modes have been studied. Some experimental verification is presented.

342. SOME COMMENTS ON WAVE PROPAGATION AND SHOCK WAVE STRUCTURE WITH APPLICATION TO MAGNETOHYDRODYNAMICS
Whitham, G. B.
Communications on Pure and Applied Mathematics, v. 12, no. 1, pp. 113–158, February 1959

343. SOME COMPRESSION WAVES IN PLASMAS
Reagan, D.
Physics of Fluids, v. 2, no. 1, p. 93, January–February 1959

Analyzes excitation of compression waves in high current discharges and applies results to data obtaining in the Harwell thermonuclear studies. (*PA*, 1959, #8256)

344. SPACE CHARGE WAVES IN HARRIS-FLOW BEAMS
Hsieh, H.
Stanford University, Palo Alto, Calif.
TR-16, June 6, 1957
Nonr-225(24), NR-373-360
407

The investigation of space-charge waves in Harris-flow beams was made under the usual assumptions of small signals and nonrelativistic velocities. Emphasis was placed on slow TM waves propagating on an axially symmetric hollow cylindrical beam focused by a radial d-c electric field. The expressions for both the plasma-frequency reduction factor and the impedance reduction factor were derived and curves plotted showing these factors as functions of the product of beam thickness and wave propagation constant.

345. SPONTANEOUSLY GROWING TRANSVERSE WAVES IN A PLASMA DUE TO AN ANISOTROPIC VELOCITY DISTRIBUTION
Weibel, E. S.
***Physical Review Letters*, v. 2, no. 3,**
pp. 83–84, February 1, 1959

The existence and rate of growth of transverse electromagnetic waves, involving only electrons in a plasma is derived from the Boltzmann transport equation. (*PA*, 1959, #7112)

346. STRUCTURE OF SHOCK FRONTS IN IONIZED GASES
Krook, M.
***Annals of Physics*, New York, v. 6, no. 2,**
pp. 188–207, February 1959

A method is given for the solution of the kinetic equations for the structure of a shock wave in an ionized gas. In an approximation of order ν, the kinetic equations are replaced by a set of $(\nu - 4)$ equations for moments of the velocity distributions. The procedure is based on a representation of the distribution functions as sums of "modified Maxwell-functions". (*PA*, 1959, #5828)

347. STRUCTURE OF A SHOCK WAVE IN FULLY IONIZED HYDROGEN
Tidman, D. A.
***The Physical Review*, v. 111, no. 6,**
pp. 1439–1446, September 15, 1958

The Fokker–Planck equations are used to examine the structure of a shock wave in fully ionized hydrogen. This is done by assuming a bimodal Maxwellian distribution for the protons in the interior of the shock and noting that the electrons are in thermal equilibrium with themselves but not necessarily with the protons. This method is essentially an extension of that used by Mott-Smith in his analysis of the Boltzmann equation for a shock wave in a gas of neutral atoms. (*PA*, 1959, #1552)

348. STRUCTURE OF WEAK SHOCK WAVES IN A MONATOMIC GAS
Talbot, L. and Sherman, F.
University of California, Institute of Engineering Research, Berkeley
R-HE-150-137 (TR), Series 19, Issue 12,
May 31, 1956

The profiles and thicknesses of normal shock waves in argon at Mach numbers of 1.335, 1.454, 1.576 and 1.713 were determined experimentally by means of a free molecule probe whose equilibrium temperature is related by kinetic theory to the local flow properties and their gradients. Comparisons were made between the experimental shock profiles and theoretical profiles calculated from the Navier–Stokes equations, the Grad 13-Moment equations, and the Chapman–Enskog third approximations equations. A new solution to the Chapman–Enskog equations was obtained for this purpose.

349. SUPERPOSABILITY IN MAGNETOHYDRODYNAMICS
Kapur, J. N.
***Applied Science Research*, Section A,**
no. 2–3, pp. 198–208, 1959 (12 ref.)

Definition of the concept of additivity and superposability of two hydromagnetic flows. It is shown that force-free fields and self-superposable fluid flows are particular cases of this concept. Chandrasekhar's equations for axially symmetric hydromagnetic flows are extended to viscous fluids, and it is shown that some important results for nonviscous flows need not hold for viscous fluids. (*A/SE*, May 1959)

350. THE ACCELERATION OF CHARGED PARTICLES IN TRAVELING OR STANDING ELECTROMAGNETIC WAVES

Askar'yan, G. A.

Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki,
v. 36, no. 2, pp. 619–621, 1959 (in Russian)

This note discusses, without going into great detail, the accelerating effect of electromagnetic waves on a plasma whose particles have a single damped resonance (e.g., plasma oscillations or cyclotron resonance). For traveling waves a formula is given indicating that the accelerating force is inversely proportional to the damping when the electromagnetic wave frequency is near the resonance frequency, but that it is directly proportional when the two frequencies are far apart. For standing waves, a net acceleration can occur only if the resonant frequency varies in space with a wavelength half that of the electromagnetic wavelength; some possible ways of achieving this are mentioned. (*PA*, 1959, #12415)

351. THE DISSOCIATION OF A PURE DIATONIC GAS BEHIND A STRONG NORMAL SHOCK WAVE

Jarre, G.
Torino Polytechnic Institute,
Applied Mechanics Lab., Italy
TN-3, November 1957
AF 61(514)-1124, AFOSR-TN-58-7
(ASTIA AD-148,046)

This paper deals with the problem of the dissociation of a pure diatomic gas produced by a strong normal shock wave. Some approximation and the recourse to a theoretical expression of the dissociation rate, allow the analytical discussion of the results. The heating and compression effects of the shock on the dissociation are analyzed at length.

352. THE FUNDAMENTAL EQUATIONS OF HYDRODYNAMICS AND SHOCK WAVES

Zwolinski, B. J.
Stanford Research Institute, Poulter Laboratories,
Menlo Park, Calif.
TR-010-56, September 10, 1956

The general differential equations of motion for continuous media are formulated, based on the principles of conservation of mass, momentum, and energy expressed in integral form. It is shown how the principle of conservation of entropy follows from the conservation laws of mechanics. The equations of motion at the shock front are derived subject to the laws of conservation of mass, momentum and energy.

353. THE INTERACTION OF A PLANE STRONG SHOCK WAVE WITH A STEADY MAGNETIC FIELD

de Leeuw, J. H.
University of Toronto, Institute of Aerophysics,
Canada
UTIA-R-49, March 1958 (80 pp., 13 ref.)

An investigation is made of some aspects of the interaction of a magnetic field and the flow of ionized and electrically conductive argon, as it may be produced in the shock tube by a strong shock wave. The following three configurations are considered: (1) a magnetic field transverse to the axis of either a rectangular or a circular shock tube; (2) an axially symmetric magnetic field as produced by a coil concentric with a circular shock tube; (3) a radial magnetic field in an annular shock tube.

354. THEORY OF EXCITED PLASMA WAVES

Sumi, M.

Journal of the Physical Society of Japan,
v. 13, no. 12, pp. 1476–1485, December 1958

The excitation of oscillations in a uniform plasma by an injected electron beam is considered. The dispersion relation for this system is derived by means of Fourier–Leplace transform method. The solutions of the dispersion relation are obtained which yield the characteristics of excited waves: the frequency, the phase-velocity and the time-rate of wave-growth as functions of the wave number. It is demonstrated that the wave characteristics are varied by the influence of thermal velocity of electrons in the main plasma and by taking the ratio of electron density in the beam to that in the main plasma over a wide range of values. It is then shown that both the velocity spread in the beam and collisions in the medium have the decaying effect on the growing wave. The case is also discussed in which the main plasma is bounded by ideally thin sheaths. (*PA*, 1959, #2429)

355. THEORY OF SPATIALLY GROWING PLASMA WAVES
Sumi, M.
***Journal of the Physical Society of Japan,* pp. 653–657, May 1959**

Investigation of the linearized theory of spatially growing waves in a uniform plasma. Characteristics of excited waves are presented by solving the dispersion relation. The growth-rate and the phase-velocity of amplified waves are examined in connection with the frequency and various conditions of the medium plasma and the directed beam. A comparison of the theory with experimental results shows good agreement. (*A/SE*, August 1959)

356. THE PENETRATION OF A SHOCK WAVE INTO A MAGNETIC FIELD
Burgers, J.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN-BN-102, June 1957, AF 18(600)-993, AFOSR-TN-57-527
(ASTIA AD-136,511)

The problem presented when a plane shock wave moves in a gas of high electric conductivity and approaches a magnetic dipole field is discussed. Five sections consider: (1) the problem when conductivity is infinite and the magnetic field reaction on gas motion is neglected; (2) with finite, large conductivity; (3) with the effect of the magnetic field on the motion of the gas close to the shock front considered; (4) the problem of the reaction of the field on the propagation of the wave; and (5) the possibility of a steady field of flow.

357. THE PRODUCTION AND STUDY OF HIGH SPEED SHOCK WAVES IN A MAGNETIC ANNULAR SHOCK TUBE
Patrick, R.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-59, July 1959
AF 49(638)-61, AFOSR-TN-59-845

A magnetic annular shock tube has been used to produce magnetically driven shock waves with very high velocities. Experiments were carried out with this device with two magnetic field configurations ahead of the shock front. For these highspeed shock waves, a shock thickness was obtained from measured rise times of the emitted visible radiation. These shock thicknesses are thinner than the mean free path in the shock-heated plasma, an observation which agrees with a theoretical prediction.

358. THE PROPAGATION OF HYDROMAGNETIC WAVES OF FINITE AMPLITUDE IN A HORIZONTALLY STRATIFIED ATMOSPHERE
Plumpton, C.
***The Astrophysical Journal*, p. 752, May, 1959**

359. THE REFLECTION OF ELECTROMAGNETIC WAVES FROM SURFACES OF COMPLEX SHAPE. I. EXPERIMENTAL STUDIES
King, R. and Wu, T.
Harvard University, Cruft Laboratory, Cambridge, Mass.
Scientific R-12, November 25, 1957
AF 19(604)-786, AFCRC TN-57-960
(ASTIA AD-133,779)

A survey made to summarize experimental research on the reflection of electromagnetic waves from surfaces of complex shape, is reported, beginning with a discussion of the elements involved in a practical problem in scattering or diffraction. These include especially the radiating source, the scattering obstacle and the probe or probes used in the measurement. Various methods of measuring the back-scattering cross section are examined as well as determinations of the diffracted field in considering reflections in arbitrary directions from an obstacle. In all cases an attempt is made to provide a brief description of the method, a critical discussion of its features and limitations, and a sample of the results.

360. THE REFLECTION OF ELECTROMAGNETIC WAVES FROM SURFACES OF COMPLEX SHAPE. II. THEORETICAL STUDIES
King, R. and Wu, T.
Harvard University, Cruft Laboratory, Cambridge, Mass.
Scientific R-13, December 20, 1957
AF 19(604)-786, AFCRC-TN-57-961
(ASTIA AD-133,780)

Theoretical research related to the reflection of electromagnetic waves from surfaces of complex shape is discussed critically, primarily in terms of those aspects to which work at Harvard University has contributed. The general nature of a diffracted field is described in detail in terms of a circular conducting cylinder with ka = 3.1. Diffraction and scattering by a conducting sphere is discussed more briefly.

361. THE RUNAWAY EFFECT IN A FULLY IONIZED PLASMA
Harrison, E.
***The Philosophical Magazine*, Eighth Series, v. 3, pp. 1318–1325, November 1958**

The conditions for producing runaway electrons in a fully ionized gas are considered, using Chandrasekhar's coefficient of dynamic friction. The runaway currents emitted continuously from linear plasmas are then estimated and are shown to be in agreement within an order of magnitude with the results from some preliminary experimental work. The rate of increase of runaway currents in closed circuits, such as toroidal plasmas, is estimated and is found to be proportional to t^2 (t = time). From some recently published results with toroidal plasmas it is shown that the runaway current, provided it is contained and is not drastically affected by the magnetic fields, can rapidly become comparable in value with the conduction current. In the experimental work with linear plasmas, X-rays were observed having an energy greater than the applied potential difference to the apparatus. (*PA*, 1959, #5831)

362. THE STRUCTURE OF A SHOCK WAVE IN A FULLY IONIZED GAS
Jukes, J. D.
***Journal of Fluid Mechanics*, v. 3, Part 3, pp. 275–285, December 1957**

The structure of a plane shock wave moving through a completely ionized plasma of protons and electrons is calculated. It is assumed that the two types of particles behave as two gases. Navier–Stokes type equations with coefficients of viscosity and thermal conductivity appropriate to the two species are solved by numerical iteration. (*Index Aeronauticus*, February 1958)

363. THE STRUCTURE OF SHOCK WAVES IN A PLASMA
Shafranov, V. D.
***Soviet Physics–JETP*, New York, pp. 1183–1188, December 15, 1957**

364. THE STRUCTURE OF A HYDROMAGNETIC SHOCK IN STEADY PLANE MOTION
Ludford, G. S. S.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN BN-131, April 1958, AFOSR TN 58-418
(ASTIA AD-158,221)

(Abstracted in *Aero/Space Engineering*, August 1958)

365. THE STRUCTURE OF HYDROMAGNETIC SHOCK WAVES. I. NONLINEAR HYDROMAGNETIC WAVES IN A COLD PLASMA
Davis, L., et al.
***Zeitschrift für Naturforschung*, v. 13A, no. 11, pp. 916–936, November 1958**

The waves in a cold (no thermal motions) quasi-neutral gas consisting of ions and electrons are treated neglecting collisions but not neglecting the inertial effects associated with the electric current. Provided the particle trajectories do not make loops, the nonlinear equations for infinite plane compressional waves traveling perpendicular to a uniform magnetic field with unchanging form and speed are reduced to a single second-order ordinary differential equation in the field strength and solved exactly. The solutions can be expressed in terms of elliptic functions. Graphs give the properties of the waves. Both wave trains and solitary waves are found, all solutions being symmetrical about maxima and minima in the field strength. The wavelengths are of the order of the gyro-radius. The velocities range from zero to twice the Alfvén velocity, higher velocities leading to looped trajectories. The relation of these waves to hydromagnetic shock waves in low density plasmas is considered and it is concluded that the entire shock will have a thickness determined by the product of mean time between collisions and the gas velocity with respect to the shock front. Two analogs of the Rankine–Hugoniot conditions are given. (*AMR*, December 1959)

366. THEORETICAL RESEARCH ON HIGH-FREQUENCY PROPERTIES OF PLASMA AND MAGNETOHYDRODYNAMIC SHOCK WAVES

Akhiezer, A. I., et al.
USSR, A/Conference/15/P/2300

Problem concerning resonance in confined plasma in cases when the projection of the wave vector in the direction of the magnetic field is other than zero or equals zero was investigated. Movement of electrons and ions, as well as collisions between them, were taken into account. It was shown that at high plasma density and high temperatures the cyclotron frequency resonance takes place according to the geometrical mean value of cyclotron frequencies of electrons and ions. The laws of penetration of electromagnetic fields into plasma and dispersion relation in case of resonance were determined and other parameters of the system were calculated. Magnetohydrodynamic shock waves were considered. Mechanical and thermodynamic conditions are discussed. Jumps of magnetic field at discontinuities and simple waves in magnetohydrodynamics were also studied. Problems concerning the excitation of hydromagnetic and magnetoacoustic waves by means of external currents were also considered. Radiation intensity, with permeability and viscosity of medium being taken into account, was determined. Comparison with other methods of excitation was made, and the kinetic theory of magnetohydrodynamic waves in plasma was developed. (*NSA*, 1959, #6578)

367. EXPERIMENTAL RESEARCH OF HIGH FREQUENCY PROPERTIES OF PLASMA AND MAGNETOHYDRODYNAMIC SHOCK WAVES

Sinelnikov, K. D., et al.
USSR, A/Conference/15/P/2211

The research on various types of electron resonance in plasma and preliminary research on ion resonance are described. Plasma density independence upon the magnetic field at a fixed frequency of the generator by means of which the burning of plasma is obtained was determined by a method of high-frequency probes. Intensity of notes was determined near and far from resonance. A problem concerning the penetration of high-frequency fields into plasma wave guides in the magnetic field was investigated. Dispersion dependence was studied. The results obtained are in conformity with theoretical calculations. A problem concerning the plasma clustering and their interaction with inhomogeneous magnetic fields was investigated. A problem concerning the reflection of electromagnetic waves moving in the wave guide from plasma was also investigated. (*NSA*, 1959, #6570)

368. THEORETICAL STUDY OF MAGNETO-HYDRODYNAMIC MAGNETO-ACOUSTIC, AND MAGNETO-ELASTIC PHENOMENA

Banos, A., Jr.
Air Force Office of Scientific Research, ARDC, Washington, D. C.
AFOSR-TR-57-35, May 15, 1957
(ASTIA AD-126,561)

An effort was made to study the soluble unbounded media and boundary value problems in the fields of magneto-acoustics, magneto-elastic waves, and magneto-hydrodynamics. The authors examined in detail the modes of propagation in (1) an ideal incompressible fluid (Alfvéns waves); (2) an ideal compressible fluid subject to adiabatic processes (magneto-acoustics); (3) an ideal elastic solid (magneto-elastic waves); (4) an incompressible fluid with finite viscosity (torsional hydromagnetic waves), and (5) a compressible fluid with finite viscosity and heat conductivity.

369. THE STRUCTURE OF A STEADY MAGNETOHYDRODYNAMIC SWITCH-ON SHOCK WAVE

Bleviss, Z. O.
University of California at Los Angeles, Heat Transfer and Fluid Mechanics Institute
June 1959

This paper solves the problem of structure of magnetohydrodynamic shocks that are normal to incident but not emergent flow, making continuum assumptions and taking a perfect gas with a scalar conductivity low enough for only the magnetic diffusivity to operate. Analysis and results are closely analogous to the well-known case of a shock without normal field component. The broad magnetic transition is terminated by a simple gas-dynamic shock if the emergent normal Mach number is subsonic. The validity of the assumptions is considered briefly. The style is admirably terse but lucid. (*AMR*, December 1959)

370. THE STRUCTURE OF STRONG COLLISION-FREE HYDROMAGNETIC WAVES

Adlam, J. and Allen, J.
***The Philosophical Magazine*, Eighth Series, v. 3, pp. 448–455, May 1958**

A theoretical study has been made of the structure of strong "hydromagnetic" waves which are propagated, across a magnetic field, in a low-density plasma, where collisions can be neglected. Under these conditions the ions are accelerated in the direction of propagation and then brought to rest again. The thickness of the wave is determined by the characteristic distance $(mc^2/4\pi ne^2)^{1/2}$ and the wave velocity lies between the Alfvén speed and twice the Alfvén speed. (*PA*, 1958, #3263)

371. THE TRANSMISSION OF STRONG SHOCK WAVES THROUGH MAGNETIC FIELDS

Dolder, K.
Atomic Energy Research Establishment, Harwell, England
Memo GP/M 199, 1957 (7 pp.)

Existing theoretical and experimental investigations of the passage of shock waves through magnetic fields are reviewed. Two procedures by which the strength of hydromagnetic interaction can be estimated are then described. In the first method equations governing hydromagnetic flow are set down and dimensionless parameters, which determine the strength of this interaction, are obtained. Values of these parameters are calculated for conditions likely to be encountered in shock tubes. The second method is based upon more detailed calculations given by Lin, and affords not only a rough quantitative guide but also a useful qualitative account of the flow pattern produced by the passage of a shock through as impressed field. (*PA*, 1958, #6069)

372. TRANSMISSION AND REFLECTION OF ELECTROMAGNETIC WAVES IN THE PRESENCE OF STRATIFIED MEDIA

Wait, J. R.
Commerce Department, National Bureau of Standards, Boulder, Colo., Boulder Laboratories
R-5541, November 15, 1957

A general analysis is presented for the electromagnetic response of a plane stratified medium consisting of any number of parallel homogeneous layers. The solution is first developed for plane wave incidence and then generalized to both cylindrical and spherical wave incidence. Numerical results for interesting special cases are presented and discussed. The application of the results to surface wave propagation over a stratified ground is considered in some detail.

373. THE TRANSMISSION OF ELECTROMAGNETIC WAVES IN THE PRESENCE OF A CONDUCTING LAYER OF GAS

Ludford, G. S. S.
University of Maryland, Institute of Fluid Dynamics and Applied Mathematics, College Park
TN BN-160, February 1959 (22 pp.)
AFOSR TN-59-159
(ASTIA AD-211,118)

Study of two related problems in electromagnetic wave transmission. (1) The reflection and transmission of plane waves at a perfectly conducting layer of gas in an otherwise nonconducting atmosphere, when there is a uniform external magnetic field perpendicular to the layer present. The main result is that a layer of finite depth h is an almost perfect filter, being transparent to waves of frequency $(n\pi A_0)/h$ (A_0 = Alfvén velocity, n an integer). (2) The existence of plane surface waves for such a finite layer. There is always one such wave and, for certain ranges of frequency, two. The first becomes "choked" at the filter frequencies, its velocity first tending to zero and then jumping to a finite value. The second chokes at the frequencies $(n\pi A_0 a_0)/h\sqrt{a_0^2 + A_0^2}$ (a_0 = acoustic velocity. (*A/SE*, May 1959)

374. TRANSMISSION OF ELECTROMAGNETIC WAVES THROUGH IONIZED AIR SURROUNDING HYPERSONIC AIRCRAFT

Bleviss, Z. O.
Douglas Aircraft Corp., Santa Monica, Calif.
R-SM-22965, October 1957

At hypersonic speeds an aircraft flying through the atmosphere will thermally dissociate and ionize the air in the neighborhood of the vehicle to some degree. The ionized air will impede the transmission of electromagnetic wave to and from the aircraft. The purpose of this study is to estimate the magnitude of the effect of the ionized air on this transmission. Transmission through two different regions on a hypersonic aircraft are studied: (1) the blunt nose region and (2) the high-speed laminar or turbulent boundary layer on a slender afterbody.

375. TRANSMISSION OF WAVES THROUGH IONIZED LAYERS

Kornhauser, E. T.
Brown University, Engineering Division, Providence, R. I.
SR-AF-4561/2, February 1959
AF 19(604)-4561, AFCR-TN-59-136
(ASTIA AD-211,150)

It is noted that an electromagnetic wave incident upon the boundary of an ionized medium in the presence of a transverse magnetic field will excite, in addition to the reflected and transmitted electromagnetic waves, a reflected sound wave and a transmitted modified sound wave. It is shown that the power coupled into these acoustic waves is proportional to the magnetohydrodynamic coupling parameter, and to the ratio of sound velocity to light velocity.

376. TRANSVERSE PLASMA WAVES AND PLASMA VORTICES

Buneman, O.
***The Physical Review*, v. 112, no. 5, pp. 1504–1512, December 1, 1958**

Plasmas at high-electron temperatures can carry transverse waves in which self-magnetic fields and relativistic effects become important. In this paper the relativistic perturbation equations for an isotropic uniform plasma are solved as an initial-value problem, i.e., by Laplace transformation, and the propagation or dispersal of both longitudinal and transverse perturbations is calculated. In both cases transients occur which have a continuous frequency spectrum. While transverse perturbations also yield pure persistent waves (with phase velocity exceeding that of light) of all wavelengths, longitudinal perturbations of very short wavelength will not be propagated as pure waves but will die out eventually with only longer wavelengths persisting. The transverse plasma perturbations discussed in the analysis are nonvortical and the dispersal of vortices is covered by a separate discussion. The vortices do not give rise to a new mode of propagation of perturbations. (*PA*, 1959, #2437)

377. UDARNAIA VOLNA SO SKACHKOM PROVODIMOSTI GAZA V ELEKTRO-MAGNITNOM POLE

Liubimov, G.
***Akademii Nauk SSSR, Doklady*, pp. 291–294, May 11, 1959 (in Russian)**

Study of stationary shock waves with a discontinuity in the gas conductivity along its front. Ahead of the shock wave the assumption is made of given parameters of the incident flow, as well as of the intensity of the electric and magnetic fields which, for simplification purposes are assumed to run parallel to the plane of the shock wave. The conductivity behind the shock wave is assumed to be infinite. On this basis, the laws of mass, momentum, and energy conservation, as well as the tangential component of the electrical field are defined. The problem of steady supersonic flow of gas around two-dimensional profiles in an external electromagnetic field is used for illustration purposes. (*A/SE*, October 1959)

378. USING ASYMPTOTIC INTEGRATION OF THE WAVE EQUATION TO SOLVE SOME WAVEGUIDE AND RESONATOR PROBLEMS

Gutman, A.
***Akademii Nauk SSSR, Doklady*, v. 125, no. 6, pp. 1252–1256, April 21, 1959 (in Russian)**

In guided-wave structures of variable cross-section where a cut-off dimension occurs and the so-called Schwarz differential is small it is possible to use the W.K.B. method of approximate solution to equations with variable parameters. Two examples are considered. The first concerns the successive widening and narrowing within a finite interval of an otherwise infinite waveguide; the second structure is semi-infinite and is in effect a resonator of tapering section between a shorting plate and a cut-off section. Some experimental results are quoted on a tapering length of septate guide which show satisfactory agreement with calculation. (*PA*, 1959, #12,513)

MAGNETO-AERODYNAMICS

379. PROSPECTS FOR MAGNETO-AERODYNAMICS
Resler, E. L., Jr. and Sears, W. R.
Journal of the Aeronautical Sciences, v. 25, pp. 235–245, April 1958; Correction in *Journal of the Aero/Space Sciences*, v. 26, p. 318, May 1959 (*Applied Science and Technology Index*, v. 47, no. 8, September 1959)

380. MAGNETOHYDRODYNAMIC EFFECTS IN AERO-DYNAMIC FLOWS
Sears, W. R.
ARS Journal, p. 397, June 1959

381. AERODYNAMIC HEATING USING THE REAL PROPERTIES OF AIR BEHIND SHOCK WAVES
Livett, R. K. and Schadt, G. H.
CONVAIR, Engineering Dept., San Diego, Calif.
R-ZR-658-024, December 23, 1958

This report discussed the development of a procedure for determining flow properties behind conical and oblique shocks which has a short computation time.

382. EXPERIMENTAL INVESTIGATION IN MAGNETO-AERODYNAMICS
Ziemer, R. W.
American Rocket Society, 13th Annual Meeting, New York, November 17–21, 1958
ARS Journal, pp. 642–647, September 1957 (10 ref.)

Study of a 3-in.-diam. electromagnetic shock tube as a means of producing the hypervelocity and ionized air flow required for magnetoaerodynamic research. It is shown that although usable test times are only about 20 microsec., velocities up to 12,000 m/sec. and stagnation temperatures up to 25,000°K are readily produced. The shock tube is used to study magnetoaerodynamic interaction in the ionized flow about a blunt body. Quantitative measurements are made of the change in the bow shock distance upon application of the magnetic field. (*A/SE*, November 1959)

383. AERODYNAMIC DISSIPATION
Petschek, H. E.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
RR23, June 1957 (21 pp., 11 ref.)

(Abstracted in *Aero/Space Engineering*, December 1958)

384. AERODYNAMIC DISSIPATION
Petschek, H. E.
Reviews of Modern Physics, v. 30, no. 3, pp. 966–972, July 1958

Flow situations in an ionized gas are classified according to the relative sizes of λ the mean free path, r_i and r_e the ion and electron Larmor radii, and l the scale length. There are four basic situations: $\lambda < r_e < r_i < l$ (S region, where normal magnetohydrodynamics apply), $r_e < \lambda < r_i < l$ (T region), $r_i < \lambda$ and $r_i < l$ (M region, where magnetic forces dominate), and $l < r_i$ (EM region). Interstellar gas clouds and the solar corona are M-region. The M-region phenomena analogous to shock waves are treated here, using Boltzmann's equation. First it is shown that the front of a broad pressure pulse will steepen until its thickness is comparable with r_i (not λ) or even less. A possible illustration of this is the sudden commencement of terrestrial magnetic storms. Next, a method of treating the steady-state structure of a weak shock is outlined, with the conclusion that a pulse, roughly r_i in width, is apparently the only possible solution. The nearest analogue of a true shock wave appears to be a train of such pulses. AVCO experiments on M-region gas dynamics are described briefly. (*PA*, 1959, #1604)

385. FLIGHT MAGNETOHYDRODYNAMICS
Kantrowitz, A. R.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
RR 51, March 1959
AF 04(647)-278, AF 49(638)-61, AFBMD-TN-59-27, AFOSR-TN-59-882

A brief discussion is given of the possible flight applications of magnetohydrodynamics and the conditions under which they might be practical.

386. MAGNETOGASDYNAMICS AND ITS POSSIBLE AERONAUTICAL APPLICATIONS
Shercliff, J. A.
Journal of the Royal Aeronautical Society, v. 63, pp. 518–521, September 1959
(*Applied Science and Technology Index*, v. 47, no. 11, December 1959)

387. MAGNETOHYDRODYNAMICS AND AERODYNAMIC HEATING
Meyer, R. X.
ARS Journal, pp. 187–192, March 1959 (15 ref.)

Discussion of the basic equations and of some fundamental concepts of magneto-aerodynamics. The flow near the stagnation point of a body of revolution is reviewed and an exact solution is given. Data are presented for the heat transfer coefficient at the stagnation point and for its gradient in the stagnation point region. The magnetic field strength required to accomplish an appreciable reduction of aerodynamic heating in hypersonic flight is discussed for the case in which ionization is due to thermal motion. Methods involving electrical breakdown of the air are considered. (*A/SE*, May 1959)

388. ON MAGNETO-AERODYNAMIC BOUNDARY LAYERS
Rossow, V. J.
Zeitschrift für angewandte Mathematik und Physik, v. 9B, pp. 519–527, March 25, 1958
(*ARS Journal*, Technical Literature Digest, June 1959)

389. PLASMA PHYSICS AND HYPERSONIC FLIGHT
Bond, J. W., Jr.
Jet Propulsion, v. 28, no. 4, pp. 228–235, April 1958

A clear review of the problems encountered at Mach numbers greater than 12 to 15. Dissociation and ionization are evaluated. Shock-front structure and boundary-layer structure are discussed as well as the conditions in which the different components of an ionized gas may be found. (*AMR*, 1959, #1035)

PROPERTIES OF IONIZED GASES

390. VELOCITY CHANGES OF CHARGED PARTICLES IN A PLASMA
Kahn, F. D.
The Astrophysical Journal, v. 129, no. 2, pp. 468–474, March 1959

391. THE DE HAAS–VAN ALPHEN EFFECT IN PULSED MAGNETIC FIELDS
Kosevich, A. M.
Soviet Physics–JETP, v. 35 (8), no. 3, pp. 512–514, March 1959
(*ARS Journal*, Technical Literature Digest, October 1959)

392. ON THE MOTION OF A CHARGED PARTICLE IN AN INHOMOGENEOUS MAGNETIC FIELD
Brinkman, H. C.
Physica Deel, v. 25, no. 10, p. 1016, October 1959

The motion of a charged particle in an inhomogeneous magnetic field is treated, employing Hellwig's and Kruskal's expansion of the gyrations of the particle in a Fourier series. The relation of various constants of motion, the energy of the particle, Kruskal's action integral and Hellwig's higher-order correction of the magnetic moment of the particle is discussed.

393. ON THE DIFFUSION THEORY OF THE POSITIVE COLUMN IN ELECTRONEGATIVE GASES
Wilhelm, J.
Naturwissenschaften, v. 45, no. 19, p. 459, 1958 (in German)

A simple electro-negative gas is considered where in addition to electrons one species of negative and positive ions is admitted as charge carriers. A balance is struck between ionization by collision with electrons, formation of negative ions by combination of an electron with a neutral particle, and loss of neutral particles as a result of dissociation initiated by a collision. The carrier distribution over the cross-section of the column has been calculated, and the solution has been found for a transition from a sink to a source inside the plasma. (*PA*, 1959, #2451)

394. ACCELERATED SELF-CONSTRICTED ELECTRON STREAMS IN PLASMA
Linhart, J. G.
Proceedings of the Royal Society of London, Series A, pp. 318–334, January 13, 1959 (14 ref.)

Analysis considering the mechanism of radial oscillations in a neutralized cylindrical electron stream of an accelerating electric field. The method is based on the two-fluid model of plasma. Analytical expressions for amplitude oscillations and numerical solutions for large amplitudes are derived. When electron-positive ion collisions are taken into account, it is found that for dense streams in low electric fields the radial oscillations (pinch oscillations) can destroy the streaming character of the electron flow and thus prevent its acceleration. (*A/SE*, March 1959)

395. AN EXTENSION OF THE TOWNSEND APPROXIMATE FORMULA FOR THE IONIZATION IN A HOMOGENEOUS ELECTRIC FELD
Neu, H.
Zeitschrift für Physik, v. 152, no. 3, pp. 294–305, 1958 (in German)

An expression is obtained for the mean spatial ionization α in terms of the value of E/p (E the field, p the gas pressure) corresponding to the minimum of the Stoletow function $\bar{S} = E/\bar{\alpha}$. This expression applies over a wider range than the well-known Townsend formula for α/p. A further expression is derived for the case of high fields, when $\bar{\alpha}$ is a function of both E/p and the applied voltage.

396. AN INVESTIGATION OF THE ENERGY OF MULTI CHARGED IONS PRODUCED BY THE IONIZATION OF GAS ATOMS BY POSITIVE IONS

Afrosimov, V. V. and Fedorenko, N. V.
***Zhurnal Teknicheskoi i Fiziki*, v. 27, no. 11, pp. 2557–2572, 1957 (in Russian) English translation in *Soviet Physics–Technical Physics*, v. 2, no. 11, pp. 2378–2390, November 1957**

A beam of A^+ or Ne^+ ions of energy $T_0 = 75$ kev was passed through a chamber filled with argon. The kinetic energy of the secondary A^+, A^{2+}, A^{3+}, A^{4+}, A^{5+}, A^{6+} ions, which arise as a result of ionization of the atoms in single collisions, was determined. Those secondary ions were investigated which are emitted at angles $77° < \phi < 90°$ with respect to the direction of the initial ion beam. It is found that the range of kinetic energy is very large: secondary ions were observed with kinetic energies ranging between fractions of and thousands of electron volts. For angles of emission $\phi < 85°$, a clear division of the secondary ions into a soft and a hard component was observed in many cases. It is shown that the possibility for the existence of both these components follows from an analysis of the energy and momentum conservation laws. The mean kinetic energy of the secondary ions of the hard component was measured as a function of the emission angle. The mean inelastic energy loss $\bar{R}$ in the collision of an ion with an atom was calculated. It was found that $\bar{R}$ may be several times greater than the sum of the ionization potentials for all the electrons of an atom which are freed in the formation of a multi-charged secondary ion. It is therefore suggested that a large amount of the kinetic energy is transferred to electrons outside the ionic and atomic shell as a result of inelastic collision. The conclusion is reached that for a given relative velocity, $\bar{R}$ is determined by the minimum separation between the nuclei of the colliding atomic particles. To a given value of $\bar{R}$ corresponds a most probable number of electrons removed from the shells of both colliding particles. (*PA*, 1959, #5841)

397. ON THE APPROACH OF ELECTRONS TO EQUILIBRIUM

Kahalas, S. L. and Kashian, H. C.
***Physics of Fluids*, v. 2, no. 2, pp. 100–102, March–April 1959**

The relaxation of electrons to equilibrium in the absence of an external field is discussed for a slightly ionized gas in which elastic collisions predominate. The gas consists of electrons and neutral molecules having a Maxwellian interaction. Spatial diffusion is neglected as well as electron–electron interaction. The change of the electronic distribution function from a simple nonequilibrium distribution to a Maxwellian distribution is followed in time. Electron attachment to neutral molecules is briefly considered. (*PA*, 1959, #8445)

398. APPARATUS FOR STUDYING CONVECTION UNDER THE SIMULTANEOUS ACTION OF A MAGNETIC FIELD AND ROTATION

Nakagawa, Y.
***Review of Scientific Instruments*, v. 28, no. 8, pp. 603–609, August 1957**

The equipment described is designed to use mercury as the working fluid in order to examine the dependence of the critical Rayleigh number for the onset of instability on the prime nondimensional magnetic and rotation parameters. The mode of the subsequent convection can also be studied. The significant nondimensional parameters can be varied over large ranges.

A few examples of typical results obtained from this apparatus are discussed. (*AMR*, 1958, #2333)

399. A RESONANT CAVITY WITH A UNIFORM FIELD SECTION

Weibel, E. S.
Space Technology Laboratories, Physical Research Lab., Los Angeles, Calif.
R-GM-TR-0127-00017, March 19, 1958
AF-04(647)-127, Call No. 2

This report is concerned with experimentally testing the predictions of a theory on the orbits of charged particles. The electro-magnetic field of a circular wave guide driven in the TE_{01} mode at cut-off is presented. This paper shows how to achieve a substantially uniform TE_{01} field over the major portion of a cavity. Proof is presented that the source free e.m. field can be generated by two scalar functions corresponding to the two polarizations. Neumann expansions of a function on specified intervals, the relations between their coefficients, and the determinantal equations relating are given.

400. A STABILIZED HIGH CURRENT TOROIDAL DISCHARGE PRODUCING HIGH TEMPERATURE

Allen, N. L., et al.
Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston Court, Berkshire
***Nature*, p. 222, January 25, 1958**

401. ATTACHMENT OF LOW-ENERGY ELECTRONS IN MIXTURES CONTAINING OXYGEN

Hurst, G. S. and Bortner, T. E.
***The Physical Review*, v. 114, no. 1, pp. 116–120, April 1, 1959**

Electron attachment to O_2 was studied for O_2–N_2 and O_2–C_2H_4 mixtures over a wide range of pressures and electric fields. It was found that α, the probability of capture per cm and per mm Hg of O_2, depends on the partial pressures of both gases in the O_2–N_2 mixture but only on the C_2H_4 pressure in the O_2–C_2H_4 mixture. The data are interpreted in terms of an extension of the mechanism postulated by Bloch and Bradbury, and by Bates and Massey, which involves first the formation of O_2^{-*} (excited by O_2^-) with subsequent collisional stabilization. On this basis estimates were made of the cross section for stabilization of O_2^{-*} by collisions with various kinds of molecules. (*PA*, 1959, #7128)

402. BREAKDOWN OF A GAS AT MICROWAVE FREQUENCIES

Herlin, M. A. and Brown, S. C.
Massachusetts Institute of Technology, Research Lab. of Electronics, Cambridge
TR-60, May 3, 1948

An electric field of sufficiently high frequency applied to electrons in a gas may deliver energy to the electrons without imparting to them any continuous drift motion due to the field. The criterion for breakdown of a low-pressure gas at microwave frequencies is therefore that ionization by collision of electrons with neutral molecules replaces loss by diffusion to the walls of the discharge tube. The condition is mathematically expressed as a simple boundary value problem. This breakdown principle is applied to converting microwave breakdown measurements into measurements of ionization rates as a function of the electric field strength, pressure, and frequency.

403. CALCULATION OF THE EFFECTIVE IONIZATION VOLTAGE IN PLASMAS

Rother, H.
***Annalen der Physik*, Leipzig, Folge 7, v. 2, no. 5–6, pp. 326–328, 1958 (in German)**

Derives an expression for the lowering of the ionization voltage resulting from impact ionization by electrons. The relevant quantum number as a function of particle density agrees satisfactorily with experimental values. (*PA*, 1959, #3592)

404. CHARGE-EXCHANGE CROSS SECTIONS OF ARGON IONS IN HYDROGEN MOLECULES

Karmohapatro, S. B.
***The Journal of Chemical Physics*, v. 30, no. 2, pp. 538–541, February 1959**

Charge-exchange cross-sections of low-energy argon ions in hydrogen are calculated by the semi-quantum mechanical impact parameter method, improved with a better approximation of the wave-functions. Cross-section curves for the reactions in different states are compared with the experimental curve so that the part of each of the different reactions in the experiment may be evaluated approximately. (*PA*, 1959, #5854)

405. CHARGE-EXCHANGE CROSS SECTIONS FOR HELIUM IONS IN GASES

Barnett, C. F. and Stier, P. M.
***The Physical Review*, v. 109, no. 2, pp. 385–390, January 15, 1958**

The charge-exchange cross-sections were determined for a helium ion beam in several stopping gases. The cross-sections for electron loss by a fast helium atom (σ_{01}) and for electron capture by an ion (σ_{10}) are reported for energies between 4 and 200 kev. The target gases studied were hydrogen, helium, nitrogen, oxygen, neon, and argon. The value of σ_{01} increases monotonically throughout the energy range for all gases studied, obtaining values of 10^{-6} cm^2 at 200 kev. In all stopping gases except helium σ_{10} passes through a maximum of approximately 3×10^{-16} cm^2 near 50 kev, whereas for helium this cross-section decreases throughout the energy range as expected for the resonant exchange reaction. Evidence is presented that the metastable excited state of the helium atom is of importance in the charge-exchange process. (*PA*, 1959, #367)

406. CHARGE TRANSFER OF PROTONS IN EXCITED ATOMIC HYDROGEN
Boyd, T. J. M. and Dalgarno, A.
***Proceedings of the Physical Society*, London, v. 72, Part 5, pp. 694–700, November 1958**

Resonance charge transfer cross sections are calculated for. (*PA*, 1959, #1562)

407. CHARGE TRANSFER FOR PROTONS IN H_2
Curran, R., et al.
***The Physical Review*, v. 114, no. 2, pp. 490–495, April 1959**

A precise measurement of the electron capture cross-section for protons in H_2 is reported for proton energies between 2.4 and 60 kev. The method involves collection of the residual ions by a sequence of identical condensers. The same scattering chamber is also used for the measurement of σ_{01} and $(\sigma_{01} + \sigma_{10})$. The recent measurements of Stier and Barnett (*PA*, 1956, #8259) are in close agreement with these results. (*PA*, 1959, #8455)

408. COHESION IN PLASMA
Cook, M. A. and McEwan, W. S.
***Journal of Applied Physics*, v. 29, no. 11, pp. 1612–1613, November 1958**

Briefly describes a study of plasma emitted from a high explosive. It is suggested that the degree of ionization in such a plasma is much higher than would be consistent with Saha's equation and that this is due to the plasma's taking up a metal-like lattice form. (*PA*, 1959, #8245)

409. CONDUCTIVITY MEASUREMENT OF DEUTERIUM PLASMAS AT MAGNETIC REYNOLDS NUMBERS GREATER THAN UNITY
Turner, E. B. and Eastmond, J.
Space Technology Laboratories, Physical Research Lab., Los Angeles, Calif.
AF 04(647)-165, December 4, 1958
R-GM-TR-0156-00514

The technique of Lin, Resler and Kantrowitz for the measurement of plasma conductivity in shock tubes has been extended to the range of magnetic Reynolds numbers of greater than unity, and has been used to measure the conductivities of deuterium and hydrogen plasmas behind shock waves in small tubes. Difficulties found in the technique and also those inherent in the problem are discussed. It was found that a measurement of the conductivity does not give much information about the fraction of ionization of the gas.

410. THE STABILITY OF A CYLINDRICALLY SYMMETRIC PLASMA CONFIGURATION WITH VOLUME CURRENTS
Hain, K. and Lüst, R.
***Zeitschrift für Naturforschung*, v. 13a, no. 11, pp. 936–940, November 1958 (in German)**

The stability is investigated by the method of small perturbations. The problem is reduced to only one eigenvalue differential equation of second order. For a special current distribution with relatively strong concentration at the axis, the eigenvalues are computed numerically. For this current distribution, particularly at long wavelengths, instability shows up. The rates of growth for different kinds of perturbations are given as a function of the wavelength. (*PA*, 1959, #2445)

411. CONDUCTIVITY OF PLASMAS TO MICROWAVES
Fang, P. H.
***The Physical Review*, v. 113, no. 1, pp. 13–14, January 1, 1959**

Plasma conductivities for electrons with a Maxwellian energy distribution are evaluated for the cases in which the collision cross-section is: (1) velocity independent and (2) inversely proportional to the velocity. The corresponding distribution functions of relaxation times are discussed. (*PA*, 1959, #4740)

412. RAPID COMPRESSION OF A PLASMA WITH AZIMUTHAL CURRENTS
Niblett, G. B. F.
***The Proceedings of the Institution of Electrical Engineers*, London, Paper 2882, April 1959**
Convention on Thermonuclear Processes
(To be republished in Vol. 106A, 1959)

Discusses a rapid pinch process in which azimuthal currents and their associated axial magnetic fields are used to heat and confine a plasma. A simple one-

dimensional model of the fast pinch process is used to show how the temperature attained by the plasma depends upon the discharge parameters and in particular that the energy per particle is proportional to the electric field developed across the plasma surface. Previous work on this form of pinch effect is reviewed and an account is given of preliminary experiments at the Atomic Weapons Research Establishment (A.W.R.E.). The principal features of a toroidal system using azimuthal currents and axial fields to heat and subsequently confine a plasma is presented and the advantages and consequences of this configuration are examined, particularly as compared with a torus using axial currents. After the initial rapid heating process the plasma and magnetic field diffuse into each other and the configuration is similar to that in the Stellarator, with similar stability problems and similar possibilities of continuous operation.

413. CORRELATIONS IN A PLASMA IN EQUILIBRIUM

Yvon, J.
***Journal de physique et le Radium*, v. 19, no. 10, pp. 733–738, October 1958 (in French)**

A fully ionized plasma in thermodynamic equilibrium is considered. An attempt is made at reviewing the calculation of spatial correlations in such a plasma. The equations of recurrence and the principle of superposition are used. The linear approximation is treated first. The next higher approximation is studied in the case of a neutral homogeneous and isotropic plasma. (*PA*, 1959, #4738)

414. DEPENDENCE OF ELECTRON MOBILITY ON MAGNETIC FIELD IN A FULLY IONIZED GAS

Sodha, M. S. and Varshni, Y. P.
***The Physical Review*, v. 114, no. 4, pp. 946–947, May 15, 1959**

The variation of drift and Hall mobilities of electrons in a fully ionized gas with magnetic field has been investigated. (*PA*, 1959, #9724)

415. DETERMINATION OF THE BINDING ENERGY OF He_2^+ FROM ION SCATTERING DATA

Mason, E. A. and Vanderslice, J. T.
***Journal of Chemical Physics*, v. 29, no. 2, pp. 361–365, August 1958**

Data on the elastic and the charge-exchange scattering of beams of He^+ ions in He gas between 4 and 400 ev are analyzed to determine precisely the interaction energies for the lowest $^2\Sigma_u$ and $^2\Sigma_g$ states of He_2^+. A Morse function is used to represent the energy for the attractive $^2\Sigma_u$ state and an exponential is chosen for the repulsive $^2\Sigma_g$ state. An attempt is made to determine the three disposable parameters strictly from the scattering data, but does not lead to a unique result. However, use of the spectroscopic value of the equilibrium distance for the $^2\Sigma_u$ state permits a unique determination, leading to interaction energies valid from about 0.9 Å to 3.8 Å. The energies are in good agreement with available quantum-mechanical calculations and give a dissociation energy of 2.16 ev for the $^2\Sigma$ state. The cross-section calculations are given in reduced units in a form readily applicable to the calculation of binding energies for similar systems as data may become available. (*PA*, 1959, #727)

416. DIFFUSION OF HYDROGEN IONS IN A UNIFORM MAGNETIC FIELD

Champion, K. S. W. and de Saint Maurice, A. B.
Tufts University, Physics Dept., Medford, Mass.
Scientific R-2, July 1, 1956
(ASTIA AD-98,751)

A new method has been used to measure ion diffusion coefficients in the presence of a magnetic field. A high power pulse discharge was produced in a small diameter quartz tube inserted into a long cylindrical microwave cavity. A specially designed coil was mounted to produce a uniform magnetic field. In a magnetic field, theory indicated two possible frequency shifts corresponding to a given electron density. In particular, if the cyclotron frequency is greater than the measuring frequency, one frequency shift should be positive and the other negative. This was verified experimentally. From this data the decay constant of the afterglow can be computed.

417. DISSOCIATIVE ATTACHMENT OF ELECTRONS IN IODINE. I. MICROWAVE DETERMINATION OF THE ABSOLUTE CROSS SECTION AT 300°K

Biondi, M. A.
***The Physical Review*, v. 109, no. 6, pp. 2005–2007, March 15, 1958**

Microwave techniques are used to study electron attachment to iodine molecules during the afterglow following a pulsed discharge in an iodine–helium mixture. The helium gas decreases the ambipolar diffusion loss of the electrons and assures that the electrons are in thermal equilibrium with the gas during the afterglow. It is shown that under the experimental conditions electron attachment is the dominant electron-loss process. The measured cross-section for electron attachment to iodine at 300°K is $\sigma_a = 3.9 \times 10^{-16}$ cm^2. (*PA*, 1959, #369)

418. DISTRIBUTION OF IONS AROUND CHARGED FINE WIRES

Shimizu, T.
***Journal of Geomagnetism and Geoelectricity*, v. 9, no. 2, pp. 116–118, 1957**
(*Physics Abstracts*, 1959, #374)

419. DISTURBANCE PHENOMENA IN PROBE MEASUREMENT OF IONIZED GASES

Okuda, T. and Yamamoto, K.
***Journal of the Physical Society of Japan*, v. 13, no. 10, pp. 1212–1223, October 1958**

There are two types of disturbance: independent of, and dependent on, probe potential. The former (inherent) disturbance has three effects which are classified: asymmetrical effect, formation effect of transition region, and the scattering effect. The latter (incidental) depends on either the negative or positive probe. In the negative probe, penetration of ion sheath into surrounding plasma is characteristic. In the positive probe, there is an unexpected change of electron current, as a result of drainage of electrons, which is observed with rise of positive probe voltage. The mechanism of collection of ions and electrons on the probe is also explained in terms of these disturbance effects. (*PA*, 1959, #12406)

420. EFFECT OF UNIMOLECULAR DECAY KINETICS ON THE INTERPRETATION OF APPEARANCE POTENTIALS

Chupka, W. A.
***The Journal of Chemical Physics*, v. 30, no. 1, pp. 191–211, January 1959**

The interpretation of appearance potential data on diatomic molecules should take account of possible effects caused by predissociation, emission of light and autoionization. In the case of complex polyatomic molecules, the kinetics of predissociation and the internal thermal energy of the molecules become especially important. The intensities of the parent, fragment, and metastable ions produced by photoionization of n-propylamine, n-propanol, and methyl ethel ketone were studied as a function of photon energy. The excess kinetic energies of the fragment ions were found to be negligibly small. The data are interpreted in terms of Rosenstock's quasi-equilibrium theory of unimolecular decomposition and indicate that the theory is qualitatively correct for the dissociative processes investigated. However, the theory is shown to be quantitatively inadequate at least in the energy range near threshold. In this region the rate constant for dissociation varies much more rapidly with energy than the theory predicts. Some of the assumptions of the theory are examined and compared to deductions from the data. The meaning of appearance potential data is examined in the light of these results. The effects of both the kinetics of dissociation and of internal thermal energy on ionization efficiency curves are significant. Most of the metals used to determine appearance potentials tend to minimize these effects and there is probably some cancellation of errors. A new method for the determination of appearance potentials is described. Experimental methods which can yield more detailed information concerning dissociation processes of complex molecular ions are suggested. (*PA*, 1959, #5842)

421. ELASTIC SCATTERING OF SLOW IONS IN THEIR PARENT GASES

McDowell, M. R. C.
***Proceedings of the Physical Society*, London, v. 72, Part 6, pp. 1087–1096, December 1958**

Total elastic scattering cross-sections for H^+, H^-, He^+, Ne^+ and A^+ in their parent gases are calculated for energies between 0.1 ev and 10 kev, by an impact parameter method. The Massey–Mohr approximation is used for the phase shifts. The cross-sections vary as the square of the logarithm of the energy above 100 ev, but at some energy between this and 0.1 ev change to an inverse one-third power dependence. Approximate interaction energies for Ne_2^+ and A_2^+ at large R are obtained from charge-transfer data. (*PA*, 1959, #2865)

422. ELECTRICAL AND PRESSURE LOSSES IN A MAGNETOHYDRODYNAMIC CHANNEL DUE TO END CURRENT LOOPS

Sutton, G. W.
General Electric Co., Philadelphia, Pa.
G-E MSVD AL TIS R 59SD431, July 22, 1959

USAF supported investigation of the problem of end losses in a magnetohydrodynamic flow for incompressible inviscid flow in a rectangular channel. Termination of the magnetic field at the electrodes leads to electrical losses which increase with decreasing aspect ratio of the electrode section of the channel. The losses are also increased with increasing values of the generator coefficient. These electrical losses can be corrected by extensions of the magnetic field beyond the electrode region, but these corrections adversely affect the net pressure change through the device. (*A/SE*, January 1960)

423. ELECTRIC AND MAGNETIC PROPERTIES OF THE HYDROGEN MOLECULE

Das, T. P. and Bersohn, R.
***The Physical Review*, v. 115, no. 4, pp. 897–910, August 15, 1959**

The hydrogen molecule ground state has been studied for a long time by valence theorists. Comparison with experiment has been limited to the energy, bond distance, vibration frequency, and the electric and magnetic polarizabilities. Recent radio-frequency experiments on hydrogen have yielded new quantities, the nuclear magnetic shielding constant, the spin–spin coupling constant, and the electric field gradient at the nucleus. In this paper, variation methods are described for the calculation of the new types of polarizability. These methods can be applied to more complex molecules and appear to open new possibilities for the semiquantitative interpretation of the results of high-resolution nuclear magnetic resonance.

An extensive comparison is made between the experimental quantities and theoretical values using various wave functions. The most important factor affecting the accuracy of the charge density is the use of an effective nuclear charge.

424. ELECTROMAGNETIC BACK-SCATTERING FROM THIN CIRCULAR DISKS BY A MICROWAVE PULSE METHOD

Tang, C. C.
Harvard University, Cruft Laboratory, Cambridge, Mass.
Scientific R-15, March 25, 1958
AF 19(604)-786; AFCRC-TN-58-110
(ASTIA AD-146,809)

The object of this research is to investigate the feasibility of adapting the conventional pulsed radar technique for close-range back-scattering measurements for obstacles of arbitrary shape and small scattering cross sections. The microwave pulse method or time-separation method described in this report differs essentially from all previously used laboratory methods in that the scattered field does not mix with the incident field since it is separated from it in time.

425. ELECTRON MOBILITY IN PARTIALLY IONIZED ATOMIC HYDROGEN

Sodha, M. S.
***The Physical Review*, v. 113, no. 5, pp. 1163–1164, March 1, 1959**

Hall and drift mobilities of electrons in partially ionized atomic hydrogen were investigated, taking into account the scattering by ions, neutral atoms, and other electrons. (*PA*, 1959, #5840)

426. ELECTRON RECOMBINATION IN ATOMIC HYDROGEN

Fowler, R. G. and Atkinson, W. R.
***The Physical Review*, v. 113, no. 5, pp. 1268–1269, March 1, 1959**

The absolute intensity of radiation of the continuum associated with the Balmer lines has been measured in a region of zero electric field by observing the expanding plasma in a shock tube. It is shown that the corresponding continuum energy can be explained by assuming that it is composed of the recombination and affinity spectrum of atomic hydrogen at a certain electron temperature. Values of the electron recombination coefficients can be derived which agree with those calculated by Cillie and disagree with those obtained from other measurements. (*PA*, 1959, #6162)

427. ENERGY DIFFUSION OF FAST IONS IN AN EQUILIBRIUM PLASMA

Kudriavtsev, J. S.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, pp. 1,558–1,565, June 1958 (Translated in *Soviet Physics–JETP*, pp. 1,075–1,079, December 1958)**

Analysis considering the energy distribution of the injected ions as initially monochromatic, with the energy exceeding the mean thermal energy in the plasma. It is assumed in this case that the distribution of velocity directions is isotropic. The extent to which the distribution approaches a Maxwellian one is determined. For an arbitrary initial distribution, the result can be obtained by the principle of superposition, since the equations are linear. (*A/SE*, March 1959)

428. ENERGY LOSS PER ION PAIR FOR PROTONS IN VARIOUS GASES
Larson, H. V.
***The Physical Review*, v. 112, no. 6, pp. 1927–1928, December 15, 1958**

Values of w for protons in A, N_2, CO_2, dry air, and "tissue-equivalent" gas were measured as 26.66 ± 0.26, 36.68 ± 0.34, 34.37 ± 0.33, 35.18 ± 0.42, and 30.03 ± 0.29 ev/ion pair, respectively. A 2 Mev positive-ion accelerator was used as the source of protons. The energy of the protons was determined with a precision gauss-meter that was calibrated by the Li(p, n) and T(p, n) threshold reactions. These protons were scattered from a gold foil into a parallel plate ionization chamber. The fast-electron pulses were collected on one electrode, amplified, and counted. The positive-ion charge was collected on the other electrode and measured by means of a standard capacitor that was connected between the input and feedback terminals of a vibrating-reed electrometer. (*PA*, 1959, #4908)

429. EQUILIBRIA IN A THERMAL PLASMA COMPOSED OF C + H_2 AND C + $2H_2$ IN A TEMPERATURE RANGE FROM 5000°K TO 50,000°K TO A TOTAL PRESSURE OF 1 BAR
Kroepelin, K. and Neumann, K. K.
RAND Corp., Santa Monica, Calif.
T-99, October 1958 (34 pp.)
***(ARS Journal*, December 1959)**

430. EXPERIMENTAL INVESTIGATION OF THE INHIBITION OF CONVECTION BY A MAGNETIC FIELD
Jirlow, K.
***Tellus*, v. 8, no. 2, pp. 252–253, May 1956**

Chandrasekhar's theory (*PA*, 1952, #6456) of stability of a layer of conducting fluid, subject to an external magnetic field and heated from below, was experimentally confirmed for mercury, in the range 0–10000 gauss. (*PA*, 1958, #8151)

431. OBSERVATIONS OF EXPLOSIONS OF HIGH-SPEED PLASMA IN A MAGNETIC FIELD
Bostick, W.
***The Astrophysical Journal*, p. 237, 1958**

432. FREE THERMAL CONVECTION OF MERCURY IN A CLOSED CIRCULAR TUBE IN A TRANSVERSE MAGNETIC FIELD
Smirnov, A. G.
***Soviet Physics–Technical Physics*, v. 3, no. 7, pp. 1429–1434, February 1959 (Translation of *Zhurnal Technicheskoi Fiziki*, v. 28, no. 7, pp. 1549–1555, July 1958, by American Institute of Physics, Inc. N.Y.)**

An experimental study is made of the effect of a homogeneous magnetic field (from 70 to 7000 gauss) on the free convective motion of mercury in a closed circular glass tube inclined at 10 deg with the vertical under certain thermal conditions.

Two cases are studied: (A) the direction of the magnetic field is perpendicular to the plane of separation of the rising and descending currents in the tube, and (B) the direction of the magnetic field is parallel to this plane. (*AMR*, 1959, #6330)

433. GENERATION OF SUPERSONIC DISSOCIATED AND IONIZED NON-EQUILIBRIUM STREAMS
Rosner, D. and Calcote, H. F.
AeroChem Research Labs., Princeton, N. J.
TM 10, October 1958 (32 pp., 10 ref.)
AFOSR TN 58-1080
(ASTIA AD-207,590)

Development of a small-scale research tool producing a steady-state, supersonic, nonequilibrium stream of atoms and ions. Fully expanded streams of air, nitrogen, argon, and helium, at Mach Numbers from 2 to 4, are studied. Preliminary measurements indicate that roughly 50 percent of the energy input is utilized in dissociating and ionizing the gas, while the over-all efficiency of the device is about 80 percent. Estimates of the resulting degree of dissociation and ionization are made. An estimate of the magnetic field strength necessary to produce easily measurable magnetogasdynamic effects on aerodynamic heat-transfer rates is also included. (*A/SE*, 1959)

434. IMPROVED MICROWAVE TECHNIQUES FOR MEASURING PLASMA PARAMETERS

Kannelaud, J. and Whitmer, R.
Sylvania Electric Products, Inc., Mountain View, Calif.
Scientific Report No. 1, July 22, 1959
AF 19 1604–4083

435. INSTABILITY AND HYSTERESIS OF THE ELECTRON TEMPERATURE IN INERT GAS PLASMAS

Gurevich, A. V.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 36, no. 2, pp. 624–626, 1959 (in Russian)**

The method developed in *PA*, 1959, #2446 is used to discuss analogous effects in weakly ionized plasmas; these occur if the frequency of electron collisions falls off sufficiently rapidly with an increase in their velocity. This condition is satisfied only in the heavier inert gases. As before, the stable electron temperature is calculated as a function of the applied field; values of the two critical fields are given for the Kr hysteresis loop. The effect is reduced by increasing the frequency of the applied field and disappears for $\omega > 1.5 \times 10^8\ p$ (p in mm Hg). The calculation is valid only for a Maxwellian electron distribution and this criterion is satisfied for a degree of ionization of $> 10^{-10}$. (*PA*, 1959, #9731)

436. INTERACTION OF SLOW ELECTRONS WITH ATOMIC OXYGEN AND ATOMIC NITROGEN

Klein, M. M. and Brueckner, M. A.
***The Physical Review*, v. 111, no. 4, pp. 1115–1120, August 15, 1958**

The polarization potential for an electron in the field of an oxygen atom was determined by utilizing recent experimental results on the binding energy of O^-. The corresponding polarization potential for atomic nitrogen has been obtained from the results for oxygen by an extrapolation based on the theory of polarization. From these results the photodetachment cross-section for O^- and the scattering cross-sections for oxygen and nitrogen were calculated. The photodetachment cross-section is in good agreement with experimental results.

The scattering cross-sections are compared with other recent calculations. It is also shown on the basis of the general theory of the photodetachment cross-section that the energy dependence of the cross-section determines the scattering length for electron scattering. The agreement of the computed photodetachment cross-section with experiment is therefore a direct check on the scattering prediction. (*PA*, 1959, #2449)

437. INTERFEROMETRIC MEASUREMENT OF ELECTRON CONCENTRATIONS IN PLASMAS

Alpher, R. A. and White, D. R.
***Physics of Fluids*, v. 1, no. 5, pp. 452–453, September–October 1958**

Plasma dispersion at optical frequencies was used to measure electron concentration in a 15 m long shock tube containing thermally ionized argon. The total refractive index was measured with a Mach–Zehnder interferometer using a 0.1 μsec spark light-source. The method is applicable for densities of 10^{16}–10^{18} electrons/cm^3. (*PA*, 1959, #2440)

438. INVESTIGATION OF AN IONIZED GAS BY MEANS OF WEAK ALTERNATING ELECTRIC FIELDS

Szekely, A.
***Acta Physica Austriaca*, v. 12, no. 2, pp. 155–171, 1958 (in German)**

A continuation of the work described previously (*PA*, 1958, #8072) by the same author. A capacitor condenser is filled with plasma and its electrical behavior is studied. Information is provided on conductivities, self-maintained oscillations in the plasma, etc. Helium at 0.5 mm Hg pressure was used. (*PA*, 1959, #1559)

439. ION DRAG PRESSURE GENERATION

Stuetzer, O. M.
***Journal of Applied Physics*, v. 30, no. 7, pp. 984–994, July 1959**

A theory of pressure build-up under unipolar ion conduction is presented and verified experimentally. Constriction of the current flow leads to sizeable pressures in insulating liquids. (*PA*, 1959, #8265)

440. IONIZATION AND DISSOCIATION OF MOLECULES BY MONOENERGETIC ELECTRONS. III. ON THE EXISTENCE OF A BENT EXCITED STATE OF NO_2^+.

Collin, J.
***The Journal of Chemical Physics*, v. 30, no. 6, p. 1621, June 1959**

(For previous work, see *PA*, 1958, #8836.) The formation of NO_2^+ from nitromethane using a monoenergetic electron beam has been studied. Results indicate that two states of NO_2^+ are formed during this dissociation. (*PA*, 1959, #9722)

441. IONIZATION IN SEEDED DETONATION WAVES

Basu, S.
Massachusetts Institute of Technology, Cambridge Mechanical Engineering Dept. Thesis
Nonr 1858(25)

This paper reports an investigation of equimolal oxyacetylene detonations at 1/10 atmosphere initial pressure, which were seeded with potassium acetylide (C_2HK) to obtain good electrical conductivity.

442. IONIZATION LOSS BY μ MESONS IN HELIUM

Lanou, R. E. Jr. and Kraybill, H. L.
***The Physical Review*, v. 113, no. 2, pp. 657–661, January 15, 1959**

The ionization loss by cosmic-ray μ mesons in helium gas was measured as a function of momentum. The ionization loss was determined with proportional counters and the momenta were measured by a magnetic spectrometer which resolved particles in the momentum region from 3.3 Bev/c to 140 Bev/c. It was found that helium gas at 2.7 atm pressure exhibits a density-effect saturation of the most probable ionization loss and that this saturation is complete at a $p/\mu c$ value of about 200. Under the conditions of normalization used in this experiment, the value of the ionization loss at which the Fermi plateau occurs is 1.28 ± 0.04 times the value at the minimum. This is in agreement with calculations based on the Sternheimer theory for the particular counter filling used in this experiment. (*PA*, 1959, #4753)

443. IONIZATION OF ARGON WITH HYDROGEN IONS

Afrosimov, V. V., et al.
***Zhurnal Tekhnicheskoi Fiziki*, v. 28, no. 10, pp. 2266–2274, 1958 (in Russian)**

Describes with details an investigation of secondary ions produced in single collisions of H^+, H_2^+ and H_3^+ in the range of 5–180 kev with A atoms. The same apparatus was used as in previous works (*PA*, 1957, #2367, #2368). It was found that: (a) in all cases total capture cross-section of electrons by H ions decreases with an increase of velocity of primary ions; (b) total formation cross-sections of $A^{++}A^{+++}A^{++++}$ reach maxima when primary ion velocities are in the region of $e^2/\hbar$; (c) total formation cross-sections of $A^{++}A^{+++}A^{++++}$ increase with increase of the charge on primary ions in the case of atomic ions; and they increase with the number of nuclei in the case of molecular ions. (*PA*, 1959, #8261)

444. IONIZATION OF ATOMIC OXYGEN ON ELECTRON IMPACT

Fite, W. L. and Brackman, R. T.
***The Physical Review*, v. 113, no. 3, pp. 815–816, February 1, 1959**

The cross-section for ionization of atomic oxygen was measured by using modulated atomic beam techniques. First the ratio of the cross-sections for production of the molecular oxygen ion and for total ion production in collisions of electrons with oxygen molecules was measured. Then the ratio of the ionization cross-section of the free oxygen atom and the cross-section for production of the molecular ion in electron-molecule collisions was determined. From the previously known total ionization cross-section of the molecule, and the measured ratios, the unknown cross-sections were determined. The experimental results are compared with the calculation of Seaton (see *PA*, 1959, #5847). (*PA*, 1959, #5848)

445. IONIZATION OF Fe XIV IN A HOT PLASMA

Schwartz, S. B. and Zirin, H.
***Physics of Fluids*, v. 2, no. 1, p. 94, January–February 1959**

Gives the results of a computation of the ionization cross section of Fe XIV by electrons. These indicate considerably smaller values than generally supposed. (*PA*, 1959, #8255)

446. IONIZATION POTENTIAL AND ABSORPTION COEFFICIENTS OF NITROGEN DIOXIDE

Nakayama, T., Kitamura, M. Y., and Watanabe, K.
***Journal of Chemical Physics*, v. 30, no. 5, pp. 1180–1186, May 1959**

Absorption coefficients of NO_2 were measured at a number of wavelengths in the spectral region 1080–2700 Å with a resolution of 0.2 Å by a photoelectric method. Several bands observed in the region 1080–1200 Å fitted a Rydberg series, and its convergence limit at 11.62 ev was interpreted as the second ionization potential of NO_2. The first ionization potential was found to be 9.78 ev by the photoionization method. The ionization continuum showed a break at 10.83 ev which may be due to a probable dissociative-ionization process. Several other electronic transitions corresponding to discrete and continuous absorption are discussed. (*PA*, 1959, #7118)

447. IONIZATION POTENTIAL OF MOLECULES BY A PHOTOIONIZATION METHOD
Watanabe, K., Nakayama, T., and Mottl, J.
University of Hawaii,
Department of Physics, Honolulu
DA-04-200-ORD-480 and 737
(Period March 1956 to December 1959)

448. IONIZATION POTENTIALS. II. THE LISITZIN EFFECT
Bedreag, G.
***Revue de Physique*, Bucharest, v. 2, no. 2, pp. 183–198, 1957 (in French)**

(For Part I see *PA*, 1957, #2357.) A discussion of the systematics of ionization potentials, particularly for cases of multiple ionization, with special reference to Lisitzin's study of isoelectronic series etc. A brief quantum-mechanical interpretation of certain regularities is given. (*PA*, 1959, #8264)

449. IONS FORMED IN A ROOM BY A POLONIUM ION GENERATOR
Norinder, H. and Siksna, R.
***Arkiv for Geofysik*, v. 2, Paper 24, pp. 501–514, 1957**

Describes a very detailed series of measurements made on the ions produced in air by a Po ion generator. The ions were classified on a mobility basis. Measurements of ion densities and rates of decay, etc., were made. The effects of air blowing were also investigated. (*PA*, 1959, #8260)

450. LONG RANGE INTERACTIONS IN IONIZED GASES IN THERMAL EQUILIBRIUM
Kahn, F. D.
***The Astrophysical Journal*, p. 205, January 1959**

451. LOW-FIELD MOBILITIES OF THE NEGATIVE IONS IN OXYGEN, SULPHUR HEXAFLUORIDE, SULPHUR DIOXIDE, AND HYDROGEN CHLORIDE
McDaniel, E. W. and McDowell, M. R. C.
***The Physical Review*, v. 114, no. 4, pp. 1028–1037, May 15, 1959**

Measurements of the low-field mobility of the negative ions in O_2, SF_6, SO_2, and HCl are described. The results are 2.46, 0.57, 0.35, and 0.71 $cm^2/(Vsec)$ respectively, reduced to 0°C and 760 mm Hg pressure. A quantum-mechanical theory of ionic mobility is outlined and applied to the gases investigated experimentally. Comparison of the experimental and theoretical results indicates that the oxygen ion is O_3^-, but attempts to identify the ions in the other gases are inconclusive. (*PA*, 1959, #9725)

452. MEASURMENTS OF DISSOCIATIVE RECOMBINATION AND DIFFUSION IN NITROGEN AT LOW PRESSURES
Faire, A. C. and Champion, K. S. W.
***The Physical Review*, v. 113, no. 1, pp. 1–6, January 1, 1959**

The measurements of recombination in nitrogen and nitrogen–helium mixtures by Faire, Fundingsland, Aden, and Champion (see *PA*, 1958, #8848) were extended using, in addition to the basic microwave techniques, a monochromator and photomultiplier to study the spectra emitted. Electron production in the afterglow due to helium metastable atoms was investigated and the results have made it possible to correct, where necessary, the apparent value of the recombination coefficient of nitrogen ions in nitrogen–helium mixtures. In addition, the ambipolar diffusion coefficient in nitrogen was determined. This has been used to correct for losses due to fundamental mode diffusion. The magnitude of higher mode diffusion is discussed and shown to be small in this experiment. The average values of the recombination and diffusion coefficients determined by this experiment are, respectively, $\alpha = (4.0 \pm 0.3) \times 10^{-7}$ cm^2 sec^{-1}, $D_a p = 220 \pm 30$ cm^2 sec^{-1} mm Hg, with an electron temperature of approximately 400°K. For pressures below 4 mm Hg it was found that the value of α was independent of pressure. (*PA*, 1959, #4757)

453. MEASUREMENT OF ELECTRON CONCENTRATION OF PLASMA IN TOROIDAL RESONATOR
Sicha, M. and Vesely, V.
***Czechoslovak Journal of Physics*, v. 8, no. 2, pp. 256–257, 1958 (in Russian)**
(*Physics Abstracts*, 1959, #4735)

454. MEASUREMENT OF IONIZATION POTENTIALS BY ELECTRON IMPACT
Nicholson, A. J. C.
***Journal of Chemical Physics*, v. 29, no. 6, pp. 1312–1318, December 1958**

Compares the different methods of extracting ionization potentials from ionization efficiency curves measured by electron impact. Conventional methods are usually accurate to ± 0.1 ev but the assumptions on which they are based are such that no further increase in accuracy can be expected. These methods sometimes give wildly inaccurate results; the main cause of this is the presence of fine structure in the ionization efficiency curve. Morrison's method of determining ionization potentials, because it detects fine structure, enables measurements accurate to ± 0.002 ev to be made. Other methods which detect fine structure are equally accurate but require more complex apparatus. (*PA*, 1959, #5843)

455. MEASUREMENT OF THE COMPLEX CONDUCTIVITY OF AN IONIZED GAS AT MICROWAVE FREQUENCIES
Alder, F. P.
California Institute of Technology, Pasadena, Thesis, May 13, 1949
(Also in *Journal of Applied Physics*, v. 20, pp. 1125–1128, 1949)

The positive column of a glow discharge is placed along the axis of a cylindrical cavity excited in the TM_{010} mode. The transmission of 3-cm waves through the cavity and the shift in resonant frequency are observed as a function of discharge current. It is shown that from these measurements values of the complex conductivity, $\sigma r + i\sigma i$, of the electron gas can be calculated. Curves of the measured conductivity components as functions of pressure and current are given.

456. MEASUREMENT OF THE EFFECT OF AN AXIAL MAGNETIC FIELD ON THE REYNOLDS NUMBER OF TRANSITION IN MERCURY FLOWING THROUGH A GLASS TUBE
Bader, M. and Carlson, W. C. A.
National Advisory Committee for Aeronautics TN 4274, May 1958 (8 pp.)

Experimental investigation which shows that the application of the magnetic field produced very little change in Reynolds number of transition when large initial disturbances were introduced at the entrance to the flow tube. However, the magnetic field increased the Reynolds number of transition by as much as 10 percent at Reynolds numbers between 5,000 and 8,000 when only slight instabilities were present; at lower Reynolds numbers this increase was not observed. (*A/SE*, 1958)

457. MEASUREMENT OF THE TEMPERATURE OF A HIGH PRESSURE ELECTRIC ARC IN A PNEUMATIC SWITCH BY A METHOD BASED ON THE PLUGGING OF THE NOZZLE
Gusa, V. and Tsigelka, I.
***Soviet Physics–Technical Physics*, v. 2, no. 5, pp. 880–886, February 1958 (Translation of *Zhurnal Tekhnicheskoi Fiziki*, v. 27, no. 5, pp. 962–969, May 1957, American Institute of Physics, Inc., N.Y.)**

A mathematical investigation is made of the temperature which would occur in an arc that fills a cylindrical nozzle. The basic assumptions for the calculations are Saha's equation to relate the fraction of ionized nitrogen to the temperature of the arc, and Steenbeck's principle of minimum electric field in the plasma as expanded and clarified by Th. Peters. In applying Saha's equation, author employes the energy step for the ionization potential of nitrogen but neglects the energy steps for the dissociation of N_2, the formation of possible molecular ions and all metastable states. In applying the Steenbeck principle which was derived for ambipolar diffusion into a gas, he replaces this gas with a metal surface. With these questionable assumptions, author's conclusions are still interesting, although probably most unreliable. (*AMR*, 1959, #1037)

458. MICROWAVE EMISSION FROM HIGH-TEMPERATURE PLASMAS
Beard, D. B.
***Physical Review Letters*, v. 2, no. 3, pp. 81–82, Februrary 1, 1959**

For plasma temperatures less than 100 kev cyclotron radiation is stated to be a negligible loss mechanism. A reason for the discrepancy with previous work is given. The emission of the fundamental cyclotron frequency and the first few harmonics should however be easily detectable and provide a means of measuring electron temperature. (*PA*, 1959, #5832)

459. MICROWAVE INVESTIGATION OF DISINTEGRATING GASEOUS DISCHARGE PLASMAS

Oskam, H. J.

***Philips Research Reports*, v. 13, no. 4, pp. 335–351, August 1958**

The phenomenon of afterglow was investigated both theoretically and experimentally by considering the shift of the resonance frequency of a microwave cavity enclosing the plasma. The following are treated theoretically: (1) the complex conductivity of a plasma at high frequencies; (2) the influence of the various loss processes on the shape of the afterglow curve; (3) the connection between the conductivity of the plasma and the properties of the cavity for various types of cavity. In measuring the frequency shift as a function of time, it is necessary to limit the power of the probing signal (frequency $\cong$ 10000 Mc) to a few μw. The construction and preparation of the gas containers and the measurements are presented. The disappearance process of the electrons from the plasma in helium is found to be ambipolar diffusion, even at a pressure of 25 mm Hg. The mobility of the He_2^+ ions in the helium at standard density is $\mu_0(He^+_2) = 17.3 \pm 0.7$ cm/s per volt/cm. In the neon afterglow, however, the electrons disappear at a pressure of 20 mm Hg by dissociative recombination with Ne^+_2 ions ($\alpha \cong 2.5 \times 10^{-7}$ cm^3/s). An admixture of atoms with a lower ionization potential than that of the main gas is found to have a great effect on the disappearance of the electrons. The afterglow is studied in the binary gas mixtures of helium with a small concentration of neon, argon, or krypton, and also in neon-argon and neon-krypton mixtures. Measurements in these mixtures all show the production of a considerable number of atomic ions of the admixture, even at very low concentrations of the latter. The process concerned in helium-neon is a charge-transfer process between a He^+_2 ion and a neon atom; the relevant cross-section is found to be $Qce \cong 1.5 \times 10^{-5}$ cm^2. In the other mixtures the atomic ions are produced by the Penning effect and possibly by the above type of charge-transfer process, which cannot be separated in the present experiment. In all gas mixtures the atomic ions are found to be converted into molecular ions by three-body collisions with an atom of the main gas and an atom of the admixer. The probability of this conversion process proves to depend strongly on the difference between the ionization potential of the main gas and that of the admixed atoms, and is found highest in helium-neon. Moreover, the measurements suggest the conversion of Ne^+ ions into $(HeNe)^+$ ions by a three-body collision with two helium atoms. (*PA*, 1959, #1549)

460. MICROWAVE MEASUREMENTS IN CONTROLLED FUSION RESEARCH

Heald, M. A.

***IRE National Convention Record*, v. 6, Part 9, pp. 14–18, 1958**

Useful information about the properties of high-temperature plasmas can be obtained by microwave techniques. Consideration of the frequency dependence of electrical characteristics of an ionized medium leads to the choice of a measurement frequency near the plasma frequency. Electron density and confinement time are measured in terms of the index of refraction of the plasma, often by means of a "free-space" microwave beam. Temperature is measured by means of thermal radiation from the plasma. (*PA*, 1959, #5829)

461. MOBILITY OF GASEOUS IONS IN WEAK ELECTRIC FIELDS

Mason, E. A. and Schamp, H. W., Jr.

***Annals of Physics*, New York, v. 4, no. 3, pp. 233–270, July 1958**

Kihara's extension (*PA*, 1954, #4560) of the Chapman–Enskog theory of transport phenomena is used to obtain the second order and third order approximations to the mobility of gaseous ions in a weak electric field as a function of temperature and field strength. In this method it is assumed that there is no charge exchange between ions and molecules, there is no clustering, and that quantum effects can be neglected. The mobility is expressed as a series in ascending powers of the square of the field strength with coefficients which are complicated functions of the temperature, the mass ratio of the ions and molecules, and of the force law between the ions and molecules. The collision integrals which enter into the coefficients have been evaluated by numerical integration

for a force law which takes into account the charge-induced dipole, charge-induced quadrupole, and the London dispersion forces, and an inverse twelfth power repulsion potential. In the potential energy function three disposable parameters specify the depth and position of the minimum, and the relative magnitudes of various terms. The results of the present calculation are then used to analyze published experimental data on mobility to obtain the disposable parameters which determine the ion-molecule force law. The agreement between theory and experiment is good except for those cases in which clustering is to be expected. (*PA*, 1959, #373)

462. MOBILITY OF HYDROGEN IONS H^+, H_2^+, H_3^+ IN HYDROGEN

Mason, E. and Vanderslice, J.
***The Physical Review*, v. 114, no. 2, pp. 497–502, April 15, 1959**

Force laws for H^+, H_2^+, and H_3^+ in H_2 are calculated from theory and from results on the scattering of low-velocity ion beams in H_2 gas. These results are then used to calculate the mobilities of the hydrogen ions in H_2 gas as a function of temperature. The mobilities of H^+ and H_2^+ decrease slightly with increasing temperature, but the mobility of H_3^+ increases strongly. The agreement with experiment indicates that the unidentified hydrogen ion whose mobility has been measured is probably H_2^+, rather than the usually assumed H_3^+. (*PA*, 1959, #8262)

463. MOLECULAR BEAM APPLICATIONS TO TRANSPORT PROPERTIES IN GASES

Estermann, I.
American Rocket Society, New York
Paper 476–57, August 1957

Conventional methods of treating transport phenomena in gaseous breakdown at very low pressures, when the mean free path of the molecules becomes equal or larger than the characteristic dimensions of the test object. For the extreme low pressure regime, molecular beam methods offer the possibility of obtaining information on energy and momentum exchange between gas molecules and solid surfaces. The fundamentals of the molecular beam method are described and prospects and limitations for application to the study of transport phenomena in gases are discussed.

464. NEGATIVE IONS OF OXYGEN

Hurst, G. S. and Bortner, T. E.
***Radiation Research*, Supplement no. 1, pp. 547–557, 1959**

Reviews methods of elucidating the mechanism of electron capture by oxygen and describes experiments using electrons of mean energy of about 1 v. The results are interpreted in terms of the formation of 2 unstable O_2^-, followed by a stabilizing process. (*PA*, 1959, #7115)

465. NEUTRON EMISSION OF HIGH CURRENT DEUTERIUM DISCHARGES

Funfer, E., et al.
***Zeitschrift für Naturforschung*, v. 13a, no. 7, pp. 524–531, July 1958 (in German)**

A 40 μf condenser bank was discharged through a column of pure deuterium. Currents of about 100 ka were obtained. The compression of the plasma was detected by current and voltage measurements and observed by a Kerr-cell camera. Neutrons were emitted by the plasma; their total number/discharge was measured by silver activation and their distribution by a fast scintillation counter. The X- and γ-rays emitted were also investigated. It was found that the plasma was contracting with velocities up to 10^7 cm/sec and emitting about 10^7 neutrons in pulses 2.5×10^{-6} sec in duration. On the basis of the results obtained, it was concluded that the plasma was in at least partial thermal equilibrium and attained temperatures of about 10^6 °K. (*PA*, 1959, #4748)

466. NEW INVESTIGATIONS WITH SCEPTRE III

***Nature*, v. 183, pp. 7–10, January 3, 1959**
"Axial Positive Ion Velocities in Sceptre III,"
Hughes, T. P. and Kaufman, S.

The Doppler widths of the OV lines excited in the toroidal discharge of Sceptre III were measured and indicated a temperature of about 10^6 °K for the plasma if the effects of broadening due to random mass motion from one discharge to another can be discounted. The shift in the wavelength of these lines when viewed tangentially to the direction of flow of positive gas current and in the

opposite direction indicated that the emitting ions were traveling with a mean velocity of between 1 and 2×10^6 cm/sec in the direction of positive gas current flow.

"Positive Ion Heating Mechanism in Sceptre III,"
Ware, A. A.

It is shown that, because of the loss of electrons to the walls of a toroidal discharge tube, the positive ions can carry an abnormal fraction of the gas current and consequently receive a substantial fraction of the energy input directly from the electric field. This could account for the fact that ion temperatures measured by Doppler broadening are much higher than estimates of electron temperatures. (*PA*, 1959, #3950)

467. NEWTONIAN DEVELOPMENT OF THE DYNAMICAL PROPERTIES OF IONIZED GASES AT LOW DENSITY

Parker, E. N.
***The Physical Review*, v. 107, no. 4, pp. 924–933, August 15, 1957**

The macroscopic dynamical equations of a tenuous ionized gas in a magnetic field are developed by averaging over the individual ion and electron motions, which do not necessarily possess an isotropic distribution. It is shown that the principal motion of the gas is related to the magnetic field by the usual hydromagnetic equations, as developed for conducting liquids and dense gases; the anisotropy of the individual particle motions shows up primarily as a coefficient multiplying the ponderomotive force exerted by the magnetic field on the plasma. The results reduce properly to the earlier work of Schüter, Cowling, and Spitzer for isotropic pressure, and are in agreement with the recent developments from the Boltzmann equation. It is pointed out that the magnetic lines of force are permanently connected and move in the frame of reference of the electric drift. It is shown that near static equilibrium, when the principal motions vanish, there remains small macroscopic drift motions of the gas in the field inhomogeneities. It is also shown that the field equations, obtained by assuming that the radius of gyration of the thermal motions is small compared to the scale of the field, are valid even near neutral surfaces, on which the field density vanishes. (*PA*, 1958, #242)

468. NOTE ON INDUCTION DRAG

Chopra, K. P.
***Journal of Geophysical Research*, v. 62, no. 1, pp. 143–146, March 1957**

Some aspects of induction drag are briefly described. The quoted expressions for translational and rotational induction drags of a sphere of infinite electrical conductivity moving in an incompressible fluid of finite electrical conductivity in the presence of a magnetic field may be derived following an earlier paper (*PA*, 1957, #8025). An analogy with the viscous drag is drawn, and it is shown that, unlike ordinary viscosity, the hydromagnetic or inductive viscosity is anisotropic in nature. A condition for this second viscosity to play an important role is also obtained. The limitations of the results obtained are discussed and it is shown that the results hold good for small bodies or weak induction currents. When applied to large bodies or strong currents, the appropriate corrections for the electromagnetic and for electrostatic shielding effects must be applied. An order of magnitude calculation shows that, for bodies of cosmical dimensions, the correction is precisely of the same order as the induction effect itself. (*PA*, 1958, #4157)

469. OBSERVATIONS ON THE PLASMA PRODUCED IN A MAGNETIC MIRROR GEOMETRY

Johnson, W. B.
***Physics Review Letters*, v. 1, no. 9, pp. 333–335, November 1, 1958**

Rotating-drum photographs were taken of the discharge in a xenon plasma excited by oscillatory current in two single-turn magnetic field coils. Maximum field at coil centers was about 50,000 gauss and mirror ratio two. The photographs are interpreted as showing the collision of two plasma fronts approaching each other from opposite directions and simultaneously collapsing towards the axis. Estimates of radial and axial velocities are given. (*PA*, 1959, #360)

470. ON APPLICABILITY OF MASSEY'S ADIABATIC HYPOTHESIS TO DOUBLE CHARGE-EXCHANGE PROCESSES

Fogel', Ya. M., et al.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, no. 3, (9), pp. 565–573, 1958 (in Russian)**

The question of applicability of Massey's adiabatic hypothesis to double charge-exchange processes is considered. An analysis of the ion-velocity dependence of the effective cross-sections for double charge-exchange of some types of ions in inert gases shows that the position of the maximum of the respective curves corresponds to Massey's adiabatic criterion. In carrying out the analysis the existence of excited ions in the primary beam, as well as the formation of slow excited doubly charged ions, should be allowed for. As in the case of the ordinary type of charge-exchange the constant (a) in the case of double charge-exchange varies slightly from one ion-molecule pair to another. The mean value of a for double charge-exchange in inert gases is 1.5 Å. The value of a for double charge-exchange in molecular gases differs sharply from this value. (*PA*, 1959, #2455)

471. ON A ROTATING PLASMA

Stepanov, V. G., et al.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 34, no. 2, pp. 512–513, 1958 (Translation by Morris D. Friedman, Inc.)**

Description of experiments with a plasma and a rotating magnetic field (3000 rpm). A mercury arc provides the plasma and a small vane indicates the rotation of the fluid. Authors note that large centrifugal accelerations are possible and that mechanical strength is not the limit. (*AMR*, 1959, #1557)

472. ON DENSITY AND ISOTROPY OF AN IONIZED GAS IN A MAGNETIC FIELD

Aström, E.
***Tellus*, v. 11, no. 2, pp. 249–252, May 1959**

The relation between the density on the surface $|v| =$ constant in the velocity space and the density in the space is treated. The relationship is given by an integral equation. First, the three-dimensional case for homogeneous magnetic field is treated, then a two-dimensional case in a magnetic field the intensity of which varies linearly with the space coordinate to show the dependence on the inhomogeneity in the field. (*PA*, 1959, #12402)

473. ONE DIMENSIONAL FLOW OF AN IONIZED GAS THROUGH A MAGNETIC FIELD

Patrick, R. and Brogan, T.
AVCO Manufacturing Corp., Research and Advanced Development Division, Wilmington, Mass.
Research R-13
AF 04(645)-18

An ionized gas is composed of electrons, ions, and neutral particles. When the motion of all three species is considered, the electrical conductivity of the gas is found to be a tensor dependent on the magnitude and geometry of the magnetic field. However, when the collision frequency for the electrons exceeds their cyclotron frequency in a magnetic field, the gas may be considered a continuum with a scalar conductivity. The latter situation is considered first, and then, using the same experimental geometries, the former is considered.

474. ON PLASMA RESEARCHES WITH AN ELECTRON BEAM PROBE OF SMALL DIAMETER

Ardenne, M., et al.
***Experimentelle Technik der Physik*, v. 6, no. 2, pp. 49–62, 1958 (in German)**

Describes a technique for probing glow discharges etc. with 35–40 kv electron beams. The electron optical system is described and illustrated. A typical discharge chamber is also shown, with a few results and discussion. (*PA*, 1959, #4700)

475. ON THE CONTINUOUS ABSORPTION COEFFICIENT OF THE NEGATIVE HYDROGEN ION. IV

Chandrasekhar, S.
***Astrophysics Journal*, v. 128, no. 1, pp. 114–123, July 1958**

(For Part III, see *PA*, 1947, #1414.) The photoionization cross-sections of the negative ion of hydrogen are revised by making use of Hart and Herzberg's 20-parameter wave-function for the ground state. The improvements over the earlier calculations based on Henrich's 11-parameter wave-function are not very great. (*PA*, 1959, #5851)

476. ON THE CONTINUOUS ABSORPTION COEFFICIENT OF THE NEGATIVE HYDROGEN ION. V

Chandrasekhar, S. and Elbert, D. D.
The Astrophysical Journal, v. 128, no. 3, pp. 633–635, November 1958

The photoionization cross-sections of the negative hydrogen ion derived in Paper IV, using Hart and Herzberg's 20-parameter wave-function, are further improved by replacing the plane-wave approximation for the free electron by the Hartree approximation. (*PA*, 1959, #5852)

477. ON THE EFFECTIVE IONIZATION POTENTIAL OF ATOMS IN A PLASMA

Theimer, O.
Zeitschrift für Naturforschung, v. 12a, no. 6, pp. 518–519, 1957 (in German)

The ionization potential is reduced in the presence of free ionization, as in a plasma, and this reduced potential is discussed briefly in terms of the Debye–Hückel theory and the more recent work of Ecker and Weizel and others. (*PA*, 1959, #7119)

478. ON THE MOBILITY OF POSITIVE IONS IN EXTREMELY PURE GASES AND GAS MIXTURES

Maushart, R.
Annalen der Physik, Leipzig, Folge 7, v. 1, pp. 264–280, 1958 (in German)

A comprehensive study at low values of electric field to gas pressure ratio in carefully cleaned apparatus. Mobilities of ions in argon–oxygen, nitrogen–oxygen and water vapour mixtures were measured. From these data information is derived on the type of ion complexes present and their change with the proportions of the mixtures. (28 refs.) (*PA*, 1959, #372)

479. ON THE MUTUAL ENERGY EXCHANGE OF CHARGE CARRIERS IN A PLASMA

Ecker, G. and Weizel, W.
Zeitschrift für Naturforschung, v. 13a, no. 12, pp. 1093–1094, December 1958 (in German)

(See also *PA*, 1959, #7119, #7120.) The authors' expression for the calculation of effective ionization potentials (*PA*, 1958, #4425) was criticized by Theimer (*PA*, 1959, #7119). The authors' reply to these criticisms on the basis of extensions to the Debye–Hückel theory. (*PA*, 1959, #7121)

480. ON THE POSSIBLE FORMATION OF H^- BY WAY OF H_2^-. I

Fischer-Hjalmars, I.
Arkiv för Fysik, v. 13, Paper 36, pp. 481–482, 1959

According to Ohman (*PA*, 1957, #34) certain high-altitude dark coronal markings can be explained as absorption structures involving the recombination of H_2 by a process of inverse pre-dissociation. It is here proposed that the pre-dissociation can occur through the following reaction:

$$H(^2s) + H(^2p) \rightarrow H_2(f^3\Sigma_u^+) \xrightarrow[\text{conversion}]{\text{internal}} H_2(d^3\Pi_u)$$

which should have a reasonable probability in the solar corona where the populations of the excited states of H are comparatively large. The more probable subsequent reactions leading to the formation of stable $H^-(^1s)$ ions are:

$$H_2(d^3\Pi_u) \xrightarrow{\text{radiation}} H_2(a^3\Sigma_g^+) +$$
$$e \rightarrow H_2^- (^2\Sigma_g^+) \rightarrow H(^2S) + H^-(^1S)$$
$$e \rightarrow H_2^- (^2\Sigma_u^+) \rightarrow H(^2S) + H^-(^1S)$$

The existence of H_2^- has never been proved experimentally. (*PA*, 1959, #4755)

481. ON THE PROPERTIES OF A RAPIDLY VARYING PLASMA

Rompe, R. and Rother, H.
Annalen der Physik, Leipzig, Folge 7, v. 3, no. 1–2, pp. 28–36, 1959 (in German)

Gives an analytical treatment of certain quantities, such as heat losses, conductivities etc., of plasmas with time-varying properties. Experiments were made with certain commercial arc lamps, the results showing reasonable agreement with the theory. (*PA*, 1959, #8244)

482. ON THE QUESTION OF THE ACCELERATION OF A PLASMA IN A MAGNETIC FIELD

Gordeev, G. and Gubanov, A.
Zhurnal Tekhnicheskoi Fiziki, v. 28, no. 9, pp. 2046–2054, 1958 (in Russian)

The plasma is contained between two coaxial cylindrical electrodes at different potentials. An external magnetic

field interacts with the resulting current, thereby rotating the plasma. The steady-state velocity and temperature fields are calculated for the case when the mean free path is less than both the electron Larmor radius and the electrode separation, using the approximation that the velocity and heat conductivity are constant. The power required to maintain the motion is calculated. Supersonic plasma motions could be produced under realizable experimental conditions. (*PA*, 1959, #3603)

483. OXYGEN VIBRATION AND DISSOCIATION RATES IN OXYGEN–ARGON MIXTURES

Camac, M. and Vaughn, A.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Report 84, December 1959

484. EXPERIMENTAL PHOTODETACHMENT CROSS SECTION AND THE IONOSPHERIC DETACHMENT RATE FOR O_2^-

Smith, S. J., Burch, D. S., and Branscomb, L. M.
***Annales de Géophysique*, v. 14, no. 2, pp. 225–231, 1958**

The results of a measurement of the photodetachment cross-section of O_2^- are described briefly. From this cross-section the photodetachment rate for O_2^- in the ionosphere is determined to be 0.44 photodetachments per ion per second. The negative ion to free electron ratio is estimated for the D-layer. Some implications for ionospheric physics of the shape of the cross-section are discussed. (*PA*, 1959, #946)

485. PHOTODETACHMENT CROSS SECTION OF THE NEGATIVE HYDROGEN ION

Smith, S. J. and Burch, D. S.
***Physical Review Letters*, v. 2, no. 4, pp. 165–166, February 15, 1959**

The variation of the cross-section for photodetachment of electrons from H^- by photons of energy from 1 to 3 ev was obtained by an improved crossed (H^- and photon) beam technique (see *PA*, 1955, #6254); the results are discussed in relation to recent theoretical computations. (*PA*, 1959, #5853)

486. PLASMA POLARIZATION AND CARRIER INTERACTION

Ecker, G. and Muller, K. G.
***Zeitschrift für Physik*, v. 153, no. 3, pp. 317–330, 1958 (in German)**

The applicability of the Debye–Hückel theory to a plasma is discussed, and limits are given as follows:

$$Z_i Z_j e^2/KTr \ll 1 \text{ (Onsager–Kirkwood relation)}$$

$$\delta = (KT)^{3/2}/12e^3\sqrt{2\pi n} \gg 1$$

For the calculation of a probability distribution for the field a separation into individual particle and collective components is carried out. It turns out that only the fraction of the individual interaction energy is important, which shows correlation to the field at the origin. This leads to differences between neutral and charged particle results. Distributions for values of δ between zero and infinity are deduced and evaluated numerically. (*PA*, 1959, #3602)

487. PRESSURE AND TEMPERATURE VARIATION OF THE ELECTRON–ION RECOMBINATION COEFFICIENT IN NITROGEN

Bialecke, E. P. and Dougal, A. A.
***Journal of Geophysical Research*, v. 63, no. 3, pp. 539–546, September 1958**

The electron-ion recombination coefficient α_{ei} in ionized nitrogen gas was investigated in the range from 0.2 to 2 mm Hg, and at electron temperatures from 92° to 300°K, corresponding to various low electron energies. At 1.3 mm Hg, α_{ei} varies from about 8.5×10^{-7} cm³/sec, at 300°K, to 6.7×10^{-6} cm³/sec, at 92°K, almost an order of magnitude difference. Discussion of the possible modes of recombination in a nitrogen gas plasma is given and dissociative recombination is found to be the most probable means of electron loss. Microwave transmission methods were used in this study. (*PA*, 1959, #2457)

488. PRESSURE DEPENDENCE OF THE SATURATION CHARGE OF POLONIUM ALPHA-PARTICLES IN CO_2 AND IN A–CO_2 AND A–CH_4 MIXTURES

Widder, F. and Huber, P.
***Helvetica Physica Acta*, v. 31, no. 6, pp. 601–624, 1958 (in German)**

The anomalous dependence of the saturation charge of Po-α-particles on pressure in ionization chambers filled with CO_2 is examined. New measurements were made with carefully purified CO_2. By means of the theory of Jaffé (1913), a graphic representation of saturation curves could be found, which gives a saturation charge independent of pressure. There the dependence of the mobility of electrons on field strength must be taken into account. Mixtures of 95% A + 5% CO_2, 70% A + 30% CH_4, and 80% A + 20% CH_4 were investigated also. These gas mixtures also show a dependence of the saturation charge of Po-α-particles on pressure when the dependence of the mobility of electrons on field strength is neglected. By taking into account the varying mobility of electrons, this dependence on pressure vanishes in the case of A–CO_2 mixture and is strongly reduced in the case of A–CH_4 mixtures. For the average energy loss per ion-pair of Po-α-particles, the following values were found: CO_2 34.0 $\pm$ 0.3 ev; 95% A + 5% CO_2 25.32 $\pm$ 0.11 ev; 70% A + 30% CH_4 27.43 $\pm$ 0.01 ev; 80% A + 20% CH_4 27.17 $\pm$ 0.12 ev. (*PA*, 1959, #7116)

489. PROPAGATION CHARACTERISTICS OF DETONATION GENERATED PLASMAS

University of Utah, Salt Lake City
ERG Report,
AFOSR TN 58-754,June 20, 1958 (32 pp.)
(ASTIA AD-201,613)

Presentation of electrical conduction measurements on a highly ionized plasma region produced by detonating high explosives. The plasma is determined to originate directly from reactions of the high explosive rather than from thermal ionization associated with the accompanying shock wave. The mechanism of conduction is considered, and it is shown that electron flow through the plasma accounted for practically all of the current. Therefore, it is concluded that the current flow through the plasma region is of the same nature as current flow in metal. Conduction measurements in atmospheres of chlorine, oxygen, nitrogen, helium, and air show that the rate of decay of the plasma is dependent upon the gaseous medium and can be explained on the basis of negative ion formation. (*A/SE*, 1959)

490. PROPERTIES OF AN IONIZED GAS OF LOW DENSITY IN A MAGNETIC FIELD III

Chandrasekhar, S., et al.
***Annals of Physics*, New York, v. 2, no. 5,**
pp. 435–470, November 1957

For previous work see *PA*, 1956, #3556. Equations are derived which describe the hydrodynamic properties of an ionized gas in a strong magnetic field and in states close to an initial stationary state. The development is based on the Boltzmann equation in which the effects of collisions between the constituents of the gas are ignored. The theory is, therefore, applicable only for following the evolution of the gas for durations which are short compared to the thermalization time. The method of solution followed is essentially one of expansion in inverse powers of the strength of the impressed magnetic field; and in the first approximation the Boltzmann equation is reducible to a one-dimensional inhomogeneous wave-equation which describes the motions of the particles along the magnetic field lines. (*PA*, 1958, #1784)

491. PROPERTES OF AN IONIZED GAS OF LOW DENSITY IN A MAGNETIC FIELD IV

Chandrasekhar, S., Kaufman, A. N., and Watson,K. M.
***Annals of Physics*, v. 5, no. 1, pp. 1–25,**
September 1958

Description of a systematic method for solving the Boltzmann equation for the steady states of an ionized gas of low density in a strong magnetic field. The solution is developed as a series in inverse powers of the gyration frequency ω, assuming that the term representing the Lorentz force in the Boltzmann equation dominates all others. The solution is explicitly carried out to the first order in ω^{-1}. Expressions for the drifts which arise in the first order are also obtained. (*A/SE*, November 1958)

492. RELATIVE BETA-RAY ENERGY LOSS PER ION PAIR PRODUCED IN WATER VAPOR AND IN AIR

Wingate, C., Gross, W., and Failla, G.
***Radiation Research*, v. 8, no. 5, pp. 411–416,**
May 1958

The ratio of the average energy loss per ion-pair produced in water vapour to that in air is deduced from measurements in the vapour and in nitrogen and a previous comparison of nitrogen relative to air (Gross, W. and Kunz, W., "Radiation Research," Vol. 5, p. 480, 1956). (*PA*, 1959, #4754)

493. RESONANCE PHENOMENA AT MICROWAVE FREQUENCIES IN GYROMAGNETIC GASEOUS DISCHARGE PLASMAS

Gilden, M. and Goldstein, L.
University of Illinois,
Engineering Experiment Station, Electrical Engineering Research Lab., Urbana
TR 9, February 28, 1956, AF 19 (604)-524

The object of this work was to investigate resonance phenomena at microwave frequencies in gyromagnetic gaseous discharge plasmas. In particular, decaying rare-gas discharge plasmas in the presence of a magnetic field were studied at microwave frequencies of about 10,000 megacycles per second. Emphasis was placed upon the intrinsic properties of the medium which are associated with the cyclotron resonance of free electrons.

494. RESPONSE OF ELECTROSTATIC PROBES TO IONIZED GAS FLOWS IN A SHOCK TUBE

Jahn, R. G. and Grosse, F. A.
***Physics of Fluids*, v. 2, no. 4, pp. 469–470,**
July–August 1959

Describes certain eccentricities of probe behaviour, thought to be due to internal potential differences in the ionized gas, and affecting the interpretation of probe measurements of charge densities in the gas. (*PA*, 1959, #12392)

495. SECONDARY IONIZATION PROCESSES IN HYDROGEN AT HIGH GAS PRESSURES

Davies, K., et al.
***Proceedings of the Physical Society*, London,**
v. 72, Part 6, pp. 1061–1073, December 1958

This paper describes accurate experimental measurements of the spatial growth of ionization in steady state conditions in hydrogen at high pressures (100 to 450 mm Hg) using an apparatus and procedure previously described (Crompton, Dutton and Haydon 1956). The values of the secondary ionization coefficient ω/α obtained from these measurements by means of the method of analysis developed in that paper show that, at a constant value of E/p (E the field, p the gas pressure), the value of ω/α is dependent both on the nature of the cathode and on the pressure of the gas. The variation in the value of ω/α with the material of the cathode shows that the predominant secondary ionization process in hydrogen at high pressures are cathode dependent processes, thus confirming the previous work. A theoretical investigation of the possible cathode-dependent processes in hydrogen shows that the variation in the value of ω/α with gas pressure may be satisfactorily explained on the assumption that the photoelectric process is predominant and that excited molecules undergo collisions of the second kind with neutral gas molecules, so that the molecular collision frequency affects the rate of production of photons. Theoretical computations of the value of ω/α based on the assumption that the photoelectric process at the cathode is the predominant secondary ionization process, and using previously measured values of the atomic constants involved, give good agreement with experiment. Measurements of sparking potentials to within 1 percent show, in agreement with theory, that such measurements are not sufficiently precise to detect the departures from Paschen's law consequent on the observed dependence of the value ω/α on gas pressure. (*PA*, 1959, #3609)

496. SECOND TOWNSEND COEFFICIENT IN OXYGEN AT HIGH PRESSURES

De Bitetto, D. J. and Fisher, L. H.
***The Physical Review*, v. 111, no. 2, pp. 390–394,**
July 15, 1958

The existence of the second Townsend ionization coefficient γ in oxygen was demonstrated in the presence of electron attachment. The experiment consisted of measurements of dc ionization currents in uniform electric fields at pressures near ½ atm and for electrode separations up to 3 cm. At a ratio of field strength to pressure of 35.4 V (cm mm Hg)$^{-1}$, γ was found to be 0.045 for a nickel cathode. This is more than an order of magnitude larger than the values previously found for a nickel cathode in hydrogen and nitrogen. This large value of γ compensates for the loss of electron multiplication due to negative-ion formation and results in comparable breakdown potentials for oxygen and nitrogen near atmos-

pheric protons in atomic hydrogen in the ground and first two excited states. The cross-sections for an excited atom are nearly an order of magnitude larger than those for the ground state. (*PA*, 1959, #1560)

497. SOFT X-RAYS FROM A MAGNETICALLY COMPRESSED PLASMA IN SCYLLA
Boyer, K., et al.
***Physical Review Letters*, v. 2, no. 7, pp. 279–280, April 1, 1959**

Observations in the Scylla plasma experiment showed that soft X-rays were emitted from the central plasma region of the discharge at the same time as the neutrons were emitted, peak emission centered exactly at the peak compression of the current cycle. The diameter of the X-ray source observed along the discharge axis agreed with the diameter of the neutron source determined previously. The energy of the X-rays was measured by absorption in thin foils of Be, Al and Ni. The intensity was determined from the X-ray pulse height in a calibrated NaI (Tl) scintillation counter, a linear approximation being made for the pulse height vs. energy characteristic at 1 kev quantum energy. The yield and spectral distribution was consistent with bremsstrahlung from a plasma at an electron temperature of 1 kev. (*PA*, 1959, #12342)

498. SOME HYDRODYNAMIC PHENOMENA ACCOMPANYING THE PASSAGE OF A CURRENT THROUGH AN INSULATING LIQUID
Ostroumov, G. A.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 30, no. 2, pp. 282–286, 1956 (*Referativnyi Zhurnal, Mekhanika*, no. 3, Rev. 3042)**

Experiments made with turpentine, benzene, nitrobenzene, petrol and transformer oil are described which have shown that, in a powerful, electric, nearly homogeneous field, these liquids are imparted a motion which does not depend on the sign of the applied voltage. (*AMR*, 1959, #473)

499. STARK BROADENING OF HYDROGEN LINES IN A PLASMA
Griem, H. R., Kolb, A. C., and Shen, K. Y.
***The Physical Review*, Second Series, v. 116, no. 1, p. 4, October 1, 1959**

500. STATISTICAL PROBLEMS IN ENERGY LOSS AND IONIZATION PROCESSES
Herring, J., et al.
***Journal of the Elisha Mitchell Scientific Society*, v. 73, no. 2, pp. 267–279, November 1957**

Relations are derived between the probability that a certain number of ion-pairs will be produced by a secondary electron of a given energy (in the electron-volt region) and the basic atomic cross-sections for excitation and ionization. Similar relations for the total number of ion-pairs produced by fast primary particles are proposed, and would entail modifications of the calculations by Moyal (*PA*, 1955, #3850). Detailed numerical results for ionization of atomic H by electrons are given. The Landau distribution of the energy of emergent particles is rederived by this method, which involves only the statistical study of the detailed processes involved, and leads to a proposal for a Monte Carlo method for obtaining the distribution. (*PA*, 1959, #8259)

501. SUM-OVER-STATES AND EFFECTIVE IONIZATION POTENTIAL INSIDE A PLASMA
Ecker, G. and Weizel, W.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 859–860, 1957 (in German)**

Clarification of an earlier paper by the authors (*PA*, 1956, #4425). Criticizes an approximate evaluation of the electrostatic interaction energy of a plasma by Theimer because it unjustifiably assumes stochastic independence of the charged particles. (*PA*, 1959, #7119–7121)

502. SUPERSONIC MOTION OF VACUUM SPARK PLASMAS ALONG MAGNETIC FIELDS
Finkelstein, D., Sawyer, G. A., and Stratton, T. F.
***Physics of Fluids*, v. 1, no. 3, pp. 188–192, May–June 1958**

Studies of plasmas produced by sparks in vacuum are reported. The observations of principal interest concern the speed with which such plasmas leave the spark. The conclusions about plasma speeds are that they are approximately ten times greater than the thermal speeds associated with spark temperature, varying between 2×10^6 and 2×10^7 cm/sec and, in the range observed, the veloc-

ities are approximately independent of the spark parameters. It is suggested that the pinch effect may be the mechanism of plasma acceleration. (*AMR*, 1959, #3102)

503. SURFACE IONIZATION OF POTASSIUM ATOMS AND KCl AND CsCl MOLECULES ON TUNGSTEN FILAMENTS IN ELECTRIC FIELDS UP TO 2 Mv/cm

Zandberg, E. Y.
***Zhurnal Tekhnicheskoi Fiziki*, v. 27, no. 11, pp. 2583–2594, 1957 (in Russian) (English translation in *Soviet Physics–Technical Physics*, New York, v. 2, no. 11, pp. 2399–2409, November 1957)**

Investigated (in cylindrical capacitors) the effect of electric field intensity on the temperature threshold. When the ionization of potassium atoms on tungsten occurs under a field intensity of about 2 Mv/cm the temperature threshold is lowered by $\sim$ 170 deg C. In electric fields of different intensities, the same degree of ionization of K, KCl and CsCl in the pre-threshold region of temperatures occurs at temperatures which decrease proportionally to $\sqrt{E}$, with increasing field intensity E of the filament. Surface ionization of potassium atoms under constant electric fields in the pre-threshold region of temperature leads, during the period of establishment of the current, to a temporary dependence of the threshold temperature on the density of potassium vapour and to a considerable temperature hysteresis in the pre-threshold regions of the ionization curve. (*PA*, 1959, #5855)

504. TABLES OF THERMODYNAMIC PROPERTIES OF AIR INCLUDING DISSOCIATION AND IONIZATION FROM 1,500°K TO 15,000°K

Hilsenrath, J., et al.
Commerce Department, Washington, D.C. National Bureau of Standards, Thermodynamics Section
MIPR-AEDC-2, AEDC-TR-59-20, December 1959

The properties tabulated are: the number of moles, $Z^* = PV/RT$, the dimensionless functions for internal energy, E^*/RT, enthalpy, H^*/RT, entropy, S^*/R, and the pressure, P, in atmospheres. Here the asterisk indicates that the properties are for the equilibrium mixture treated as an ideal gas (without so-called van der Waals effects). The underlying equations for this work and the input data are discussed briefly.

505. THE ATTACHMENT OF SLOW ELECTRONS IN AIR AND OXYGEN

Tozer, R., Thorburn, R., and Craggs, J. D.
***Proceedings of the Physical Society*, London, v. 72, Part 6, pp. 1081–1086, December 1958**

Calculations are presented to show that a satisfactory explanation of electron attachment coefficients, under low-current discharge conditions, and for values of X/p greater than 10 $V\ cm^{-1}\ (mm\ Hg)^{-1}$ in both air and oxygen can be obtained if it is assumed that attachment takes place only in the form of resonant dissociative attachment to oxygen, and that a Maxwellian distribution of electron velocities exists in the electron swarm in discharges where the X/p values lie in the range $10 < X/p < 60$. Use of the electron drift and agitation velocity data of Crompton, Huxley and Sutton (1953) and of Townsend and Tizard (1913) shows better agreement with the calculations given here in the case of the latter workers' results. (*PA*, 1959, #2452)

506. THE DISPERSION OF A CURRENT ON THE SURFACE OF A HIGHLY CONDUCTING FLUID

Stewartson, K.
***Proceedings of the Cambridge Philosophical Society*, v. 53, Part 2, pp. 544–545, April 1957**

By means of an example, it is shown that if the normal component of the magnetic field is non-zero at the free boundary of a perfectly conducting fluid, then a discontinuity in the magnetic field would be dispersed instantaneously as an Alfvén wave in the fluid. It is concluded that under these conditions the tangential components must be continuous at the free boundary. (*PA*, 1958, #5132)

507. THE ELECTRON CAPTURE CROSS SECTIONS FOR PROTONS IN HELIUM

Haywood, C. A.
***Proceedings of the Physical Society*, London, v. 73, Part 2, pp. 201–214, February 1959**

The impact parameter formulation of the method of perturbed stationary states is used to calculate the cross-section for electron capture by protons in helium. The σ–σ transition from ground state to ground state is inves-

tigated. A one-body formulation is used in which the captured electron moves initially in the combined field of the other electron, the helium nucleus and the incident proton. The presence of the passive electron is allowed for by using as the initial wave-function before the collision, an approximation to that calculated from the self-consistent field for the helium atom. During the collision this initial wave-function is modified by the introduction of a variational parameter which is determined by a minimization condition for the energy. The possibility of using the one-body formulation for more complex systems is demonstrated by calculations of the electron-capture cross-section for protons in argon and neon. (*PA*, 1959, #2453)

508. THE ELECTRICAL AND THERMAL CONDUCTIVITIES OF XENON HIGH PRESSURE PLASMA

Schirmer, H.

***Technisch-Wissenschaftliche Abhandlungen der Osram-Gesellschaft*, v. 7, pp. 8–10, 1958 (in German)**

Data are presented for a pressure of 25 atm. The electrical conductivity, and the components of the "total thermal conductivity" and their sum, are given for temperatures ranging up to 9000°K. (*PA*, 1959, #7106)

509. THE EXPERIMENTAL DETERMINATION OF THE PRIMARY IONIZATION COEFFICIENTS AT LOW GAS PRESSURES

Jones, E. and Jones, L.

***Proceedings of the Physical Society*, London, v. 72, Part 3, pp. 363–368, September 1958**

An assessment of the method used to measure values of the Townsend primary coefficient of ionization at low pressures is given. This shows that the secondary processes of ionization must, in general, be taken into consideration in the analysis of the data, especially at pressures of the order of a few mm Hg, in order to obtain accurate values of α/p_0. (*PA*, 1959, #366)

510. THE IONIZATION PRODUCED BY BEAMS OF CARBON AND NITROGEN IONS

Burcham, W. E. and Alves, M. A. F.

***Proceedings of the Physical Society*, London, v. 72, Part 3, pp. 462–466, September 1958**

A study of ionization produced by carbon and nitrogen ions, of up to 80 Mev energy, in argon. Experimental data agree well with theory except for higher beam energies. The theory is semi-empirical in certain respects, but its relevance to other published work is discussed. (*PA*, 1959, #3605)

511. THE MICROFIELD ON A NEUTRAL PARTICLE IN THE PLASMA

Ecker, G. and Muller, K.

***The Astrophysical Journal*, v. 129, no. 3, pp. 858–860, May 1959**

The probability distribution for the electric field acting on a neutral particle in a plasma has been calculated using the physical ideas of the Debye–Hückel theory. The results are presented graphically for various integral values of a parameter δ, the number of particles in the Debye region. (The Holtsmark distribution corresponds to $\delta = \infty$). The results are compared with those of previous less accurate calculations carried out by Ecker and by Hoffman and Theimer. (*PA*, 1959, #8250)

512. THE MOBILITY OF NEGATIVE IONS IN AIR

Balog, I. I. and Dzherpetov, Kh. A.

***Zhurnal Tekhnicheskoi Fiziki*, v. 28, no. 6, pp. 1263–1266 (in Russian)**

Investigations are described of mobility in dry air and in air containing different concentrations of water vapour at E/p (E = field strength; p = pressure) of up to 35 V/cm mm Hg. For dry air, the mobility at low E/p remains constant up to a certain critical value of E/p when it increases to a maximum after which it shows a gradual decrease. For moist air, the mobility at low E/p decreases with E/p; this is due to formation of complex ions. (*PA*, 1959, #3611)

513. THEORY OF ELECTROSTATIC PROBES IN A LOW DENSITY PLASMA

Bernstein, I. and Rabinowitz, I.

***Physics of Fluids*, v. 2, no. 2, pp. 112–121, March–April 1959**

The theory of spherical and cylindrical probes immersed in plasmas of such low density that collisions can be neglected is formulated. The appropriate Boltzmann equation is solved, yielding the particle density and flux as functionals of the electrostatic potential, the situation in the body of the plasma, and the properties of the probe. This information when inserted in Poisson's equation serves to determine the potential, and hence the probe characteristic. No *a priori* separation into sheath and plasma regions is required. Though amenable to a determination of the full probe characteristic, the method is applied in detail and numerical results are presented only for the collection of monoenergetic ions, for the case of negligible electron current. These results indicate that the potential is not so insensitive to ion energy as was believed, and that if the probe radius is sufficiently small, there enters the possibility of a class of ions which are trapped near the probe in troughs of the effective radial potential energy. The population of these trapped ions is determined by collisions, however infrequent. It is difficult to calculate, and conceivably can have a marked effect on the local potential. (*PA*, 1959, #8248)

514. THEORIES OF GAS TRANSPORT PROPERTIES

Hirschfelder, J. O., et al.
American Rocket Society, New York
Paper 468-57, August 1957

In the first section a discussion is given of intermolecular forces, with particular reference to the empirical potential energy functions, their utility, and their limitations. In the second section the transport properties of dilute gases are discussed. The principal comments to be made are in regard to the corrections for internal degrees of freedom of polyatomic molecules. In the third section the transport properties of dense gases are discussed, with special reference to some recent developments in kinetic theory as well as in corresponding states correlations.

515. THE PLASMA CONDENSER

Schumann, W. O.
***Zeitschrift für Naturforschung*, v. 13a, no. 10, pp. 888–895, October 1958 (in German)**

A theoretical analysis of the behavior of a "plasma-filled" condenser. It is shown how the maximum electron density in the plasma, and the minimum electron density at the walls of the tube carrying the discharge through the condenser, may be determined by electrical measurements. The effect of a superimposed magnetic field, in the discharge direction, is also considered. (*PA*, 1959, #5836)

516. THERMAL CONDUCTIVITY OF AN ELECTRON GAS IN A GASEOUS PLASMA

Sekiguchi, T. and Herndon, R. C.
***The Physical Review*, v. 112, no. 1, pp. 1–10, October 1, 1958**

The thermal conductivity of an electron gas in a gaseous plasma is determined by experimental techniques which have been improved over those reported by Goldstein and Sekiguchi (*PA*, 1958, #2369). A pulsed microwave is utilized to probe the plasma parameters as well as to selectively heat up the electron gas in a small volume of the elongated plasma. The photomultiplier tube detects the change in electron temperature by taking advantage of the phenomenon of "afterglow quenching." The experimental values for the thermal conductivity, which are determined by two different methods, are in good agreement. In the plasmas investigated, neon and helium, the degree of ionization is very low (10^{-5}–10^{-6}). However, the measured values of the thermal conductivity are still consistent with those obtained from the theoretical expression given by Landshoff, or Spitzer and Härm for a fully ionized gas. (*PA*, 1959, #2264)

517. THE RUNAWAY EFFECT IN A FULLY IONIZED PLASMA

Harrison, E. R.
***The Philosophical Magazine*, Eighth Series, pp. 1318–1325, November 1958**

Study of the conditions for producing runaway electrons in a fully ionized gas by considering Chandrasekhar's coefficient of dynamic friction. The runaway currents emitted continuously from linear plasmas are then estimated and shown to be in general agreement with results from some preliminary experimental work. The rate of increase of runaway currents in closed circuits, such as toroidal plasmas, is estimated and found to be proportional to t^2 (t = time). (*A/SE*, 1959)

518. THE THERMODYNAMIC PROPERTIES OF A DEGENERATE PLASMA

Vedenov, A. A.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 36, no. 2, pp. 641–642, 1959 (in Russian)**

Using the diagrammatic method developed by Matsubara for the statistical Green's functions, the author calculated the interaction correction to the thermodynamic potential of a completely ionized hydrogen plasma. It was assumed that the average scattering amplitude in the Coulomb field was less than the distance R between particles, i.e., $e^2/R\bar{E} \equiv \alpha \ll 1$. The potential is expressed as an expansion in powers of α. The second term of this represents the electron exchange energy while the third represents the self-consistent interaction. (*PA*, 1959, #9732)

519. TRANSPORT PHENOMENA IN COMPLETELY IONIZED GAS CONSIDERING ELECTRON–ELECTRON SCATTERING

Sodha, M. S. and Varshni, Y. P.

***The Physical Review*, v. 111, no. 5, pp. 1203–1205, September 1, 1958**

Hall mobility and other transport properties of electrons in a completely ionized gas were investigated when a magnetic field is applied, taking into account electron–electron scattering. Results are presented for different mean ionic charges. (*PA*, 1959, #2433)

520. TRANSPORT PHENOMENA IN A COMPLETELY IONIZED TWO-TEMPERATURE PLASMA. APPENDIX—CALCULATION OF MATRIX ELEMENTS

Braginskii, S. I.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, pp. 459–472, August 1957 (Translation in *Soviet Physics–JETP*, pp. 358–369, February 1958)**

Presentation of a system of transport equations for a plasma consisting of electrons and one kind of positive ions placed in an electric and magnetic field. The system includes the continuity equations, equations of motion, and the equation of heat transport for electrons and ions. The case of arbitrary ratio of the particle collision frequency to the Larmor frequency is considered. The method given by Chapman and Cowling is somewhat modified to obtain a separate system of transport equations for each plasma component. (*A/SE*, July 1958)

521. TRANSPORT PROPERTY EQUATIONS FOR PARTIALLY IONIZED GASES

Baulknight, C.

General Electric Co., Missile and Space Vehicle Dept., Schenectady, N.Y.

Doc. R59SD423, September 18, 1959

Two types of systems are considered in this theoretical investigation. Type I is a system of charged–charged particles and the Coulombic interaction potential is assumed. In type II the system is composed of both charged and uncharged particles, i.e., N^+ N, and $1/r^4$ potential is assumed. The $1/r^4$ term is corrected for probabilities. Some typical results are presented in the temperature range of 10,000 to 15,000°K.

ION-MOLECULE COLLISION STUDIES

522. ON THE PROBLEM OF THE TECHNIQUE OF MEASUREMENT OF THE EFFECTIVE CROSS-SECTIONS OF PROCESSES OF FORMATION OF NEGATIVE IONS BY ATOMIC COLLISIONS
Fogel', Ya. M., Mitin, R. V., and Kozlov, V. F.
***Zhurnal Tekhnicheskoi Fiziki*, v. 28, no. 7, pp. 1526–1537, 1958 (in Russian)**

The method used was to pass a fine beam of positive ions, after passage through a magnetic monochromator and a collimator, into a chamber containing gas at low pressure in a uniform magnetic field. All of the negative ions from a known length of the positive-ion-beam path, defined by the dimensions of the apparatus, were deflected by the magnetic field to an insulated electrode. The ratio of this negative current to the primary positive current then gave the proportion of positive ions undergoing double-charge-transfer. With the help of this method was measured the cross section for this process for ions of H^+ from about 4 to 50 kev in hydrogen and krypton, and for ions of C^+, O^+ and Cl^+ (from 10 to 50 kev) in krypton. Agreement was obtained with mass-spectrometer methods, the cross section obtained having values between 10^{-19} and 10^{-16} sq cm. The results showed that the double charge-transfer caused only a very small angular deflection of the negative ions formed from the path of the primary beam. (*PA*, 1959, #3610)

523. COLLISION CROSS-SECTION STUDIES ON MOLECULAR GASES AND THE DISSOCIATION OF OXYGEN AND WATER
Lassettre, E. N.
***Radiation Research*, Supplement no. 1, pp. 530-546, 1959**

Gives a general review, with a theory of scattering, of an experimental programme of work on electron scattering. An apparatus is described which enables velocity analysis on the scattered electrons, for a variable scattering angle, to be made. Results are shown for helium and oxygen. Collision cross sections, oscillator strengths and dissociation (of water and oxygen) are also briefly discussed. (See also *PA*, 1959, #5164.) (*PA*, 1959, #7130)

524. CAPTURE AND LOSS OF ELECTRONS IN COLLISIONS BETWEEN FAST CARBON AND OXYGEN ATOMS WITH GAS
Fogel', Ya. M., Ankudinov, V. A., and Pilipenko, D. V.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, no. 4(10), pp. 368–374, 1958 (in Russian)**

The effective cross sections for capture and loss of electrons by carbon and oxygen atoms with energies from 10 to 65 kev experiencing collisions with atoms of He, Ne, A, Kr, Ze and H_2, N_2 and O_2 molecules were measured. The effective cross section for capture of an electron by fast atoms is found to increase with increase of the affinity energy of the atom. The effective cross section for electron loss by fast atoms nonmonotonically depends on the first ionization potential of the atom. Massey's adiabatic criterion is valid for electron capture processes by fast atoms. The constant a for these processes is 3 Å. (*PA*, 1959, #2456)

525. COLLISION OF TWO HIGHLY IONIZED CLOUDS OF GAS
Kahn, F. D.
***Reviews of Modern Physics*, v. 30, no. 1, pp. 1069–1071, July 1958**

Numerical cross section estimates indicate that two gas clouds on colliding will quickly ionize each other. Next, the counterstreaming of electrons will be converted to plasma oscillations almost at once, by a mechanism described previously (*Journal of Fluid Mechanics*, v. 2, p. 601, 1957). Finally the proton counterstreaming will also be converted to plasma oscillations (this is demonstrated theoretically using the simplification that the electrons are at rest). A criterion for the relative importance of plasma oscillations and collisions is given, and its modification to allow for the presence of a magnetic field is discussed. (*PA*, 1959, #2002)

526. DIFFUSION AND ELASTIC COLLISION LOSSES OF THE "FAST ELECTRONS" IN PLASMAS

Medicus, G.

Journal of Applied Physics, v. 29, no. 6, pp. 903–908, June 1958

When the energy spectrum of plasma electrons consists of two clearly separable groups (a high-energy, primary, non-Maxwellian, and a low-energy, secondary, Maxwellian one) the characteristic linear part of the corresponding probe curves, extrapolated to plasma potential, directly determines the random current density of the fast group. With a hemispherical anode and a hollow hot cathode near its center, in Ne of about 1 mm Hg pressure, the flow of the fast group at low diode currents follows closely the spherical case of diffusion. The experimental data, by means of the diffusion law, can be evaluated for the mean free path 1 of the fast electrons. It is found that 1 is independent of the plasma density and is about equal to the value calculated from the cross section function for 10−16 V electrons in Ne. The diffusion law being applicable, the elastic collision losses of the fast group can be calculated. They are found to be relatively small compared with the total energy losses of the fast electrons. The results have been used in an attempt to determine the energy transfer from the fast group to the Maxwellian group. The most remarkable result is the low interaction of the fast group with the Maxwellian group at low total plasma densities where the partial density of the slow group is always comparable to or even much higher than that of the fast group. (*PA*, 1959, #356)

527. ELECTRON IMPACT IONIZATION OF Ne, O, AND N

Seaton, M. J.

The Physical Review, v. 113, no. 3, p. 814, February 1, 1959

The Bethe approximation gives a functional relation between the cross sections for electron impact ionization (Q) and photoionization (a). Estimates of Q_N and Q_0 are obtained using experimental values for Q_{Ne} and calculated values for a_N, a_0 and a_{Ne} (*PA*, 1959, #5847)

528. FORMATION OF H^- IONS BY ELECTRON IMPACT ON H_2

Schulz, G. J.

The Physical Review, v. 113, no. 3, pp. 816–819, February 1, 1959

The cross section for production of H^- ions by electron impact in hydrogen gas is studied. The cross section exhibits a plateau around 10 ev with a value of 1.2×10^{-20} cm^2. A sharp peak with a cross section of 3.5×10^{-20} cm^2 is observed at 14.2 ± 0.1 ev. The first plateau is associated with the reaction $H_2 + e \rightarrow H^- + H$ and the sharp peak with the production of hydrogen atoms in the first excited state, $H_2 + e \rightarrow H^* + H^-$. (*PA*, 1959, #5849)

529. IONIZATION PRODUCED BY ATOMIC COLLISIONS AT keV ENERGIES. II

Russek, A. and Thomas, M. T.

The Physical Review, v. 114, no. 6, pp. 1538–1540, June 15, 1959

The electron evaporation model, presented in Part I (*PA*, 1958, #8846), of the collision-ionization process that occurs when atoms collide at high energies is extended and improved. In addition, an alternative model of the process is considered. This second model treats the collision-ionization process as being due to direct knock-outs of the electrons by violent electron–electron collisions. It is found that this model cannot be made to account for the data, thereby lending additional support to the assumptions inherent in the evaporation model. (*PA*, 1959, #12399)

530. MICROWAVE METHOD FOR MEASURING THE PROBABILITY OF ELASTIC COLLISION OF ELECTRONS IN A GAS

Hirshfield, J. L. and Brown, S. C.

Journal of Applied Physics, v. 29, no. 12, pp. 1749–1753, December 1958

A plasma in a dc magnetic field has a transverse conductivity component whose reactive part depends, as to both magnitude and sign, on the strength of the magnetic field. By measuring the value of magnetic field that is necessary for bringing this reactive part to zero – and hence removing any resonant-frequency shifts of a TE_{011} mode of a cylindrical cavity containing the plasma – determination of the probability of elastic collision of electrons in helium is obtained as a check on the method. The value of $P_m = 20 \pm 1$ cm^{-1} mm Hg^{-1} for the electrons at room temperature thus obtained agrees substantially with the value obtained by previous workers. Sources of error in the measurement are discussed. (*PA*, 1959, #5830)

531. TOTAL CROSS SECTIONS FOR MULTIPLE ELECTRON STRIPPING IN ATOMIC COLLISIONS AT ENERGIES TO 100 keV

Jones, P. R., et al.
***The Physical Review*, v. 113, no. 1, pp. 182–191, January 1, 1959**

Total cross sections were measured for electron capture and stripping of He^+, Ne^+, and A^+ ions in single collisions of He^+ on He, Ne, and A; Ne^+ on Ne and A; and A^+ on A. Where He^+ ions are incident the cross sections are given for electron capture, σ_{10}; for electron loss, σ_{12}; and for "elastic" scattering in excess of one degree, $\sigma_{11} > 1°$. Where Ne^+ and A^+ are incident the cross sections for multiple stripping $\sigma_{13} \ldots, \sigma_{17}$ are given also. The measurements were made at 25, 50, and 100 kev and at additional energies in two cases where a maximum in the electron capture cross section was observed. Each total cross section was compiled by adding the contributions from the various angular regions into which the incident particle may be scattered. The contribution from the particles scattered between 0 and 1° was measured directly, while that for regions in excess of 1° was obtained by integrating the measured differential cross sections. In the region between 1 and 4° the differential cross section for each process was measured with high resolution and these data are presented here separately. These differential measurements supplement data previously published for angles in excess of 4° (*PA*, 1959, #5986; 1957, #8687). Tables are presented showing the contribution of each of the angular regions to the various total cross sections. Large-angle scattering is found to make a significant contribution to the total cross sections for the production of the more highly ionized particles. (*PA*, 1959, #4752)

532. MULTIPLE IONIZATION OF SODIUM VAPOR BY ELECTRON IMPACT

Dibeler, V. H. and Reese, R. M.
***Journal of Chemical Physics*, v. 31, no. 1, pp. 282–283, July 1959**

Ionization probability curves are shown for the Na^+, Na^{++} and Na^{+++} ions, the first power, square root and cube root of the respective ion currents being plotted against thee electron energy. The Na^{++} ion current follows a square law and the Na^{++} ion current a cubic law to approximately 30 ev above threshold. The extrapolated ionization potentials for the three ions are 5.14, 52 ± 1 and 125 ± 2 ev respectively, in good agreement with spectroscopic results. A 14-stage electron multiplier replaced the usual ion collector in these measurements. (*PA*, 1959, #9723)

533. ON THE RELATION BETWEEN HOLTSMARK'S MICROFIELD DISTRIBUTION FUNCTION AND THE CUTOFF VALUE OF THE COLLISION PARAMETER IN FULLY IONIZED GASES

Theimer, O. and Hoffman, H.
***The Astrophysical Journal*, p. 224, January 1959**

The Coulomb field with cutoff at $r = p_m$, commonly used for analyzing encounters of charged particles in a plasma, is replaced by a field which, on the basis of certain assumptions, is fully determined by the microfield distribution first introduced by Holtsmark (1919). Using a shielded Holtsmark distribution (Hoffman and Theimer, 1957) a scattering potential of the form

$$\Psi(r) = Zer^{-1}\exp(-ar)\cos 2.53n^{1/3} r$$

is obtained, where Ze and n are the charge and total concentration of the ions and a is a parameter depending on n and the temperature T. The diffusion coefficient $\langle(\Delta w\perp)^2\rangle$ (Spitzer 1956) is calculated fro mthis potential, and the result is presented in terms of an equivalent cutoff parameter satisfying the approximate relation

$$p_m = 156\, T^{-1/2}\, n^{-1/3}$$

for most cases of practical interest. Here p_m may be a thousand times smaller than the Debye shielding constant at high temperatures and low ion densities.

SPECTROGRAPHIC STUDIES

534. A MASS SPECTROMETRIC STUDY OF NORMAL OXYGEN AND OXYGEN SUBJECTED TO ELECTRICAL DISCHARGE

Herron, J. T. and Schiff, H. I.
***Canadian Journal of Chemistry*, v. 36, no. 8, pp. 1159–1170, August 1958**

A mass spectrometric study was made of oxygen activated by microwave and by ac glow discharge. Appearance potential curves for normal oxygen at masses 16 and 32 indicated the occurrence of multiple electron impact processes. The change in the curves when the oxygen was activated could be interpreted by assuming the presence of O-atoms in the P^3 ground state, and O_2 molecules in the $^1\Delta g$ excited states. No evidence was obtained for the presence of ozone up to pressures of 2 mm Hg. The recombination coefficient of O-atoms on pyrex was found to be 1.1×10^{-4}. Only one oxygen atom in 21 was ionized before recombining in the mass spectrometer ion source. The rate constant for the reaction of O-atoms with N_2O is less than 1×10^{-8} cm^3 $mole^{-1}$ sec^{-1}, and several orders of magnitude less than this for the reaction $O(^3P) + N_2O \rightarrow 2NO$. The reaction of O-atoms with NO_2 was much faster than with NO, but no evidence was found for the formation of NO_3. (*PA*, 1959, #363)

535. APPEARANCE POTENTIAL OF BF_3^+ AND BF_2^+ FROM BF_3 BY ELECTRON COLLISION

Kreuzer, H.
***Zeitschrift für Naturforschung*, v. 12a, no. 6, p. 519, 1957 (in German)**

Mass spectrometer studies in $A - BF_3$ mixtures give the ionization potential of BF_3 as 15.5 ± 0.3 ev and the appearance potential of BF_2^+ as 16.25 ± 0.2 ev. (*PA*, 1959, #5844)

536. ENERGY SPECTRUM OF ELECTRONS EMITTED FROM GASES BOMBARDED BY POSITIVE IONS

Moe, D. E. and Petsch, O. H.
***The Physical Review*, v. 110, no. 6, pp. 1358–1361, June 15, 1958**

The energy spectrum of electrons ejected during ionization of neon, argon and krypton by bombardment with potassium ions was experimentally determined. Energy selection was effected by the focusing property at 180 deg of a uniform magnetic field. The observed spectra consist of a structure of maxima and minima characteristic of the bombarded gas. The relative heights but not the positions of the maxima are functions of the incident ion energy. (*PA*, 1959, #368)

537. FUNDAMENTAL RESEARCH ON ELECTROMAGNETIC THEORY AND MICROWAVE SPECTROSCOPY

National Council of Research, Center of Study for the Physics of Microwaves, Florence, Italy
TN-7, December 15, 1956
AF 61(514)-903 AFCRC-TN-191
(ASTIA AD-117,108)

During the first part of this project, work was done to improve the apparatus for high-pressure spectroscopy and to study its properties. The apparatus was then employed for measuring the absorption coefficients and the refractive indices of a number of gases and gaseous mixtures.

538. IONS IN NITROGEN

Saporoschenko, M.
***The Physical Review*, v. 111, no. 6, pp. 1550–1553, September 15, 1958**

N^+, N_2^+, N_3^+, and N_4^+ ions were identified in nitrogen gas by use of a mass spectrometer operated with the ion source in the pressure range from 10^{-3} mm Hg to 0.6 mm Hg. Appearance potentials occur at 15.5 ± 0.2 ev for N_2^+, at 15.8 ± 0.3 ev for N_4^+, at 22.1 ± 0.5 ev for N_3^+, and at 24.2 ± 0.4 ev for N^+; N_3^+ ions thus are formed only at much higher electron energies than N_2^+ but still at 2 ev less energy than N^+. It is believed that the N_4^+ is formed by the process $N_2^+ + N_2 \rightarrow N_4^{+*}$ (excited vibrationally) and the N_3^+ is formed by the process $N_2^{+*} + N_2 \rightarrow N_3^+ + N$ where N_2^{+*} is an excited ion. N_4^+ and N_3^+ currents decrease with increasing E/p in the source, suggesting

that they may be dissociated by molecular impacts. The N_4^+ ions are considerably more readily lost than the N_3^+ ions. Since the formation of N_3^+ must necessarily release a nitrogen atom, this process constitutes a form of dissociation of N_2 which may account for the value of the dissociation energy of 7.38 ev found by some methods. (*PA*, 1959, #3606)

539. MASS SPECTROMETRIC ANALYSIS. MOLECULAR REARRANGEMENTS

McLafferty, F. W.

***Analytical Chemistry*, v. 31, no. 1, pp. 82–87, January 1959**

Structure determination by mass spectrometry has been hampered by the relatively unpredictable possibilities of molecular rearrangement. Classification of such anomalies as more random or more specific rearrangements is proposed. The former appear to involve a higher energy reshuffling process in which various atoms or groups are equilibrated in the molecule. The latter can yield either specific ions of high abundance through formation of a sterically favorable transition state or more stable products. Further classification according to whether the ions and neutral species involved contain an odd or even number of electrons has been useful in correlating these rearrangements. Mechanisms are proposed for several rearrangement classifications. (*PA*, 1959, #3604)

540. MASS-SPECTROMETRIC INVESTIGATION OF THE REACTION $X^+ + H_2 \rightarrow H^+ + H$

Gutbier, H.

***Zeitschrift für Naturforschung*, v. 12a, no. 6, pp. 499–507, 1957 (in German)**

It was found that the rate of formation of HX^+ (where X is He, Ne, A, Kr, N_2, O_2 or CO_2) is proportional to concentrations of H_2 and X^+ and inversely proportional to the velocity of X^+ ions. For the mean kinetic energy of the ions, amounting to $E_{kin} = 0.25$ ev, the measured cross sections are of the order of magnitude of 10^{-15} cm^2. (*PA* 1959, #7129)

541. MASS SPECTROMETRIC STUDY OF Al_2O_3

De Maria, G., Drowart, J. and Inghram, M. G.

***Journal of Chemical Physics*, v. 30, no. 1, pp. 318–319, January 1959**

With an alumina liner inserted in a tungsten cell the following ions have been observed: O^+, O_2^+, Al^+, AlO^+, Al_2O^+, WO^+, WO_2^+, and WO_3^+, the ratio AlO^+/Al_2O^+ being close to 1. Small intensities of ions from impurities have also been noted. Over liquid Al_2O_3 at 2475°K the molecule Al_2O_2 was also observed. Its appearance potential was found to be essentially equal to that of AlO, its pressure to be about 1/200 that of AlO. The atomization energy for gaseous Al_2O_3 has been estimated to be 500 kcal/mole. (*PA*, 1959, #7123)

542. MASS SPECTRUM OF ACETYLENE PRODUCED BY 5.1 MeV ALPHA PARTICLES

Melton, C. E. and Rudolph, P. S.

***Journal of Chemical Physics*, v. 30, no. 3, pp. 847–848, March 1959**

The use of alpha-particles to produce ions in a mass spectrometer gives a much simplified mass spectrum as compared to the use of 75 ev electrons. This technique is therefore advantageous for analytical application. (*PA*, 1959, #7125)

543. ON HYDROMAGNETIC EQUILIBRIUM

Woltjer, L.

***Proceedings of the National Academy of Sciences of the U.S.A.*, v. 44, no. 9, pp. 833–841, September 1958**

It is shown that, in the absence of external fields and dissipative processes, the hydromagnetic equations admit six integrals in addition to the energy integral; one integral corresponds to the fact that the parallel components of the magnetic and velocity fields do not interact, and others express conservation of angular momentum and mass. Equations for stable dynamical equilibrium are obtained by minimizing the total energy, keeping constant the other six integrals of motion. It is concluded that in general non-force-free solutions involve non-zero velocity fields. (*PA*, 1959, #1599)

544. ON NITROGEN IONS IN A PLASMA

Dreeskamp, H.

***Zeitschrift für Naturforschung*, v. 12a, no. 11, pp. 876–881, 1957 (in German)**

A simple double-focusing spectrometer (resolving power 50) was used to investigate the nitrogen ions formed in a low pressure discharge. Only N^+ and N_2^+ were observed. However, in a drift tube experiment N_3^+ ions

were also observed. These results are discussed in the light of a theoretical investigation. (*PA*, 1959, #2444)

545. ON THE INTERACTION BETWEEN A MEDIUM AND A RING CURRENT INCIDENT ON IT

Tsytovich, V. N.

***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, no. 6(12), pp. 1407–1416, 1958 (in Russian)**

The spectral distributions of the current in a ring which impinges with a constant relativistic velocity on a medium possessing arbitrary $\epsilon(\omega)$ and μ, are analyzed. The reflection criterion for non-relativistic velocities and expressions for the acting forces are deduced. (*PA*, 1959, #12507)

546. PHOTOIONIZATION ANALYSIS BY MASS SPECTROSCOPY

Weissler, G. L., Samson, J. A. R., Ogawa, M., and Cook, G. R.

***Journal of the Optical Society of America*, v. 49, no. 4, pp. 338–349, April, 1959**

A vacuum ultraviolet monochromator was combined with a mass spectrometer to study photoionization processes between 1570 and 430 Å. Monochromatic photons were used to ionize, A, He, Ne, O_2, N_2, CO, NO, CO_2, N_2O, and NO_2; and preliminary measurements of ion intensity as a function of photon energy were obtained for the parent ions together with their fragments. The appearance of ionization and the structure of curves, in which ions per unit photon flux vs λ are plotted, will be related to previously reported energy levels, to photoionization cross sections, and to dissociative photoionization mechanisms. (*PA*, 1959, #7126)

547. SOME EXACT SOLUTIONS OF THE EQUATIONS OF MAGNETOHYDRODYNAMICS WHEN BOTH SELF-ATTRACTION AND MAGNETIC FIELDS ARE PRESENT

McVittie, G. C.

***Reviews of Modern Physics*, v. 30, no. 3, pp. 1080–1082, July 1958**

In the first type of solution, which contains one arbitrary function, an infinite slab of gas moves with velocity proportional to t but independent of position. The current and density are proportional, vanishing at both faces. In the second type of solution, which also contains one arbitrary function, an infinite cylinder expands and contracts radially with velocity proportional to r at constant t. Oscillatory solutions are given for which the density, pressure, and magnetic field vanish at the surface of the cylinder. (*PA*, 1959, #1602)

548. STRUCTURE OF SPECTRAL LINES FROM PLASMAS

Margenau, H. and Lewis, M.

***Reviews of Modern Physics*, v. 31, no. 3, pp. 569–615, July 1959**

Careful review of the theoretical methods that have been used to study the broadening of spectral lines of optical frequencies emitted in strongly ionized media. The relation between the two main types of theory, the statistical and impact theories, is pointed out, and their respective regions of applicability indicated, by discussing a more general approach of which they are special cases. Various refinements and particular applications of the theories are presented, and the results discussed, as are some relevant experimental results and their interpretation (100 ref.).(*PA*, 1959, #12021)

PLASMA DIFFUSION

549. THERMAL DIFFUSION IN IONIZED GASES

Chapman, S.

***Proceedings of the Physical Society*, London, v. 72, Part 3, pp. 353–362, September 1958**

Thermal diffusion in mixed gases depends on a "thermal diffusion factor" α, which is less than unity in all known neutral gas mixtures (in which the particles have no electric charge). In simple ionized gases α exceeds unity, being of order $Z + 1$, where Ze is the charge on the ions. However, in the steady state of such a gas, at non-uniform temperature, thermal diffusion does not produce a concentration gradient of the electrons relative to the ions; instead it sets up an electric field, which keeps the gas electrically neutral almost everywhere. In an ionized atmosphere subject to gravity, in which the temperature increases upwards, this electric field opposes and reduces the electric field that keeps the electrons and ions together, despite the great difference between their masses. The thermal diffusion factor seems to be greatest for the ions of different kinds in a mixed ionized gas, composed mainly of electrons and light ions of small charge Ze, with a small admixture of heavy ions of greater charge $Z'e$. In this case α is of order 2.5 $(Z'/Z)^2$, and can amount to several hundred. In such a gas, at non-uniform temperature, thermal diffusion can much increase the (still small) proportion of the heavy multiple ions in the hotter regions. The electric field that keeps the electrons with the ions, so that the gas is neutral, reinforces this tendency of the multiple ions, in the cases here considered. This tendency may have some importance in the solar corona, if turbulence is not too great and temperature inequalities persist long enough. It seems likely also that thermal diffusion will influence the distribution of the multiple ions present in the Zeta nuclear fusion apparatus. (*PA*, 1959, #365)

550. DIFFUSION OF A PLASMA ACROSS AN INHOMOGENEOUS MAGNETIC FIELD

Bastick, W. M., Weintraub, H., et al.

Tufts College, Physics Dept., Research Laboratory of Physical Electronics, Medford, Mass.

Scientific R-11, AF 19(122)-89, September 15, 1953 (ASTIA AD-28,798)

The movement of a plasma across a magnetic field $\vec{H}$ in the direction of $-\text{grad } 1\vec{H}1$ by means of plasma waves or magneto-hydrodynamic waves is analyzed.

551. AMBIPOLAR DIFFUSION IN A POSITIVE COLUMN

Pahl, M.

***Zeitschrift für Naturforschung*, v. 12a, no. 8, pp. 632–642, 1957 (in German)**

A detailed theoretical study of ambipolar diffusion, based on the earlier work of Schottky, Spenke and others. The effects of volume recombination and wall recombination are included. The results of computations are exhibited graphically. (*PA*, 1959, #5835)

552. AN INVESTIGATION OF THE ELECTRON COMPONENT OF ELECTRON AVALANCHES

Frommhold, L.

***Zeitschrift für Physik*, v. 156, no. 2, pp. 144–158, 1959 (in German)**

The oscilloscopic study of pulses due to the electron component of avalanches in homogeneous fields confirms that the number of electrons increases exponentially with time. By measuring the drift velocity v_- and applying recent measurements of the first Townsend coefficient α, the time constant τ was found to be $1/\alpha v_-$. One obtained the axial diffusion radius of the electron swarm and thus the mean energy of agitation (0.4 to 0.7 ev) and the cross section for electron impact. Space charge influence becomes apparent with carrier numbers of about 10^7 electrons, attenuating the time rate of further growth of the avalanche. This is in accordance with earlier work. The investigation was made with methane in the range of E/p from 28 to 58 V cm^{-1} (mm Hg)$^{-1}$, with pd-values from 50 to 1500 cm (mm Hg), with mean gas amplification from e^{12} to e^{17}, and with gap widths of 2, 3 and 6 cm. (*PA*, 1959, #12401)

553. THE DIFFUSION OF MAGNETIC FIELDS IN A CYLINDRICAL CONDUCTOR

Adlam, J. H. and Tayler, R. J.
Atomic Energy Research Establishment, Harwell, England, T/M160, 1958 (12 pp.)

The conventional stabilized pinched discharge requires axial and azimuthal magnetic fields which are to a high degree separated. The finite electrical conductivity of the discharge causes these fields to diffuse into one another. The (simple) present discussion states that significant field-mixing occurs in an electromagnetic penetration time τ determined by the relevant electrical conductivity. It is also shown what fraction of τ is important in stability problems. By regarding the discharge as an incompressible fluid of uniform conductivity, sufficient field diffusion to lead to loss of stability can occur in times of the order of $10^{-3}\tau$. (*PA*, 1959, #5957)

554. EFFECT OF CHARGE SEPARATION ON PLASMA DIFFUSION IN A STRONG MAGNETIC FIELD

Kaufman, A. N.
***Physics of Fluids*, v. 1, no. 3, p. 252, May–June 1958**

A brief analysis is presented to test the assumption that in a low-density fully ionized plasma, confined by a magnetic field, the effects of charge separation on the plasma diffusion are negligible. The results show that the induced field satisfies a diffusion-like equation and, to the order of the approximation, becomes constant after a finite time. The value of this induced field is proportional to not only the total charge at the point, but also to the fractional change in the number of particles over a Debye radius. When this charge separation field is constant the diffusion flux of ions vanishes. By accounting for ion-electron collisions as well as electron-electron collisions it is found that the effects of charge separation are small and the standard assumption is valid.

The practical consequence of the analysis discussed above is to affirm the generalizations that are based upon the customary assumptions in plasma analysis. (*AMR*, 1959, #466)

555. ENERGY DIFFUSION OF FAST IONS IN AN EQUILIBRIUM PLASMA

Kudriavtsev, V. S.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 34, no. 6, pp. 1558–1565, 1958 (in Russian)**
(Translated by Morris D. Friedman, Foreign Technical Translations, West Newton, Mass., K-183, 9 pp.)

Author considers the problem of the energy diffusion of fast ions injected into an equilibrium plasma. The initial conditions for the energy distribution of the injected ions is a monochromatic distribution with the values exceeding the mean thermal energy in the plasma. The distribution over the velocity directions is isotropic. The kinetic equation for a completely ionized plasma in the absence of external field is taken from the well-known Landau paper (*Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 7, p. 203, 1937). The influence of the mutual particle collisions is assumed to be small and the time-variation of the distribution function of these particles is determined by the collisions with the ions and electrons of the equilibrium plasma distributed according to a Maxwellian law. This leads to an expression for the particle flux in the velocity space and to an equation for the energy density distribution. The latter equation is solved by means of the Laplace transform and an approximate assumption for the form of the energy density. The final expression for the energy density describes the energy distribution of the ions injected into the plasma being in an equilibrium state. The result for an arbitrary initial distribution can be found by using the superposition principle since the equations are linear.

556. ON THE DIFFUSION OF A CONDUCTING FLUID ACROSS A MAGNETIC FIELD

Rose, M. H.
New York University, Institute of Mathematical Sciences, AEC Computing Facility
NYO-7691, AT(30-1)-1480, July 1, 1956
Atomic Energy Commission, Technical Information Service

The purpose of this report is to examine the concepts upon which diffusion theory is based and, in particular, to show that the rate of diffusion of a conducting fluid across a magnetic field is independent of the field if the proper scaling is used.

557. ON THE DISPERSION RELATION FOR ELECTRON PLASMA

Voloshinskii, A. and Lobelev, L.
***Fizika Metallov i Metallovedenie Akademiia Nauk S.S.S.R.*, v. 6, pp. 356–358; 1958 (in Russian)**
***(Nuclear Science Abstracts*, 1959, #4024)**

PLASMA HEATING

558. ARC-HEATED PLASMA FOR LABORATORY HYPERSONICS
Hogness, T. R.
Astronautics, v. 4, pp. 40–42, 47, March 1959
(*ARS Journal*, Technical Literature Digest, p. 992, December 1959)

559. A NON-THERMAL DIRECT-CURRENT PLASMA HEATING MECHANISM
Reagan, D.
Nature, v. 183, p. 102, January 10, 1959

Traveling hydromagnetic waves in a plasma contain magnetic potential wells in which electrons can be trapped. Energy fed to these electrons by an applied dc electric field will, under suitable conditions, enhance the waves. (*PA*, 1959, #12409)

560. STRONG HYDROMAGNETIC DISTURBANCES IN A COLLISION-FREE PLASMA
Dungey, J. W. (King's College, Newcastle Upon Tyne, England)
The Philosophical Magazine, v. 8, no. 4, pp. 585–593, May 1959

An attempt is made to extend the exact pulse solutions at zero temperature to finite temperatures, and the heating of the plasma is studied. A linear treatment shows that the increase in the temperature is small except for very strong pulses. An approximate treatment of the gas pressure is found to be invalid for strong pulses at the experimental values of the initial temperature. Discussion of the ions which start with large thermal velocities shows that some of them are likely to gain energy, but that their effect on the field may be important at the experimental values. (*NS*, 1959, #15204)

561. DISCUSSION OF THE SIMPLIFYING ASSUMPTIONS INTRODUCED IN THE STUDY OF THE HEATING OF A THIN CYLINDRICAL CONDUCTING LAYER BY A HIGH FREQUENCY SINUSOIDAL UNIFORM MAGNETIC FIELD
Gourceaux, M.
Comptes rendus hebdomadaires des seànces de l'académie des sciences, Paris, v. 247, no. 20, pp. 1720–1721, November 17, 1958 (in French)
(*Physics Abstracts*, 1959 #4830)

562. EXPERIMENTS ON ION CYCLOTRON RESONANCE
Stix, T. H. and Palladino, R. W.
Physics of Fluids, v. 1, no. 5, pp. 446–451, September–October, 1958

Theoretical calculations indicate that an attractive possibility for heating the ions of a plasma directly, swiftly, and efficiently is to feed energy into ion cyclotron waves and cause this wave energy to thermalize. Experiments at the milliwatt power level verify the existence of a resonance in a helium plasma at the cyclotron frequency of the doubly charged helium ion. The variation of the plasma loading with magnetic field strength is markedly asymmetrical, in agreement with the theory of ion cyclotron wave generation. The observed plasma loading indicates an efficiency of power transfer between the induction coil and the plasma greater than 60 percent. (*PA*, 1959, #2439)

563. FLUID MOTIONS IN A SPHERE. I. THERMAL INSTABILITY OF A ROTATING FLUID SPHERE HEATED WITHIN
Namikawa, T.
Journal of Geomagnetism and Geoelectricity, v. 9, no. 4, pp. 182–192, 1957

A fluid with negligible viscosity is examined. It is found that stationary convections cannot exist. Instability first sets in as over-stability. (*PA*, 1959, #3658)

564. FLUID MOTIONS IN A SPHERE. II. THERMAL INSTABILITY OF A CONDUCTING FLUID SPHERE HEATED WITHIN UNDER A UNIFORM MAGNETIC FIELD
Namikawa, T.
Journal of Geomagnetism and Geoelectricity, v. 9, no. 4, pp. 193–202, 1957

Axially symmetric steady state solutions exist and only $(U_n^m, V^m{}_{n+1}, \ldots)$ motions can arise. Calculation suggests a relation between perturbations in the magnetic field and vorticity. Under normal terrestrial conditions, instability arises as ordinary cellular convections, but under astrophysical conditions, it can arise (depending on intensity of the uniform magnetic field) as cellular convections or as overstability oscillations of increasing amplitude. (*PA*, 1959, #3659)

565. FLUID MOTIONS IN A SPHERE. III. THERMAL INSTABILITY OF A ROTATING FLUID SPHERE HEATED WITHIN UNDER A UNIFORM MAGNETIC FIELD

Namikawa, T.

Journal of Geomagnetism and Geoelectricity, v. 9, no. 4, pp 203–209, 1957

The influence of simultaneous action of Coriolis force and magnetic field on convection is examined. It is found that there is only axially symmetric solutions of the marginal stability, and inhibition of convection by a magnetic field is pronounced when the intensity of magnetic field is larger than a critical value. (*PA*, 1959, #3660)

566. HEATING OF A CONFINED PLASMA BY OSCILLATING ELECTROMAGNETIC FIELDS

Berger, J. M., et al.

Physics of Fluids, v. 1, no. 4, pp. 301–307, July–August, 1958

There are two ways of heating a plasma confined by a strong axial magnetic field: (1) the electric field is parallel to the magnetic field, the situation that obtains in ohmic heating; (2) the electric field is perpendicular to the main axial magnetic field. In this paper the second method is considered for the case where the electric field is produced by an externally imposed oscillation of the axial field. As far as the heating of the plasma is concerned, there are four characteristic times which play a fundamental role: (1) the collision time, (2) the period of the oscillating field, (3) the time of transit of a typical ion through the heating region, and (4) the cyclotron period of an ion. If these four characteristic times are all of comparable order, the theoretical analysis is exceedingly complex. Therefore, four cases were considered in which these were taken to be of different orders. The heating mechanism differs in each of these four cases since the period of the externally produced electric field is chosen to be comparable to one of the characteristic times in the analysis. In each of the four cases configurations were found which led theoretically, at least, to efficient heating of the plasma. In those cases where the energy imparted to the plasma appears in the form of wave motion, the subsequent damping of these waves is discussed. (*PA*, 1959, #358)

567. HEATING AND CONFINEMENT OF A PLASMA BY A MAGNETIC FIELD OF EXTERNAL ORIGIN AND WITH A SHORT RISE TIME

Loos, H. G.

Physical Review Letters, v. 2, no. 7, pp. 282–283, April 1, 1959

Calculates in cylindrical geometry, the line density of atoms necessary for a skin depth, thin compared to the tube radius, and necessary for the ion-ion collision time to be short compared to the skin decay time. Values quoted are 2 and 50 $\times$ $10^{14}cm^{-1}$ for the two cases respectively. (*PA*, 1959, #12411)

568. MOLLIER ENTHALPY-ENTROPY CHARTS FOR HIGH TEMPERATURE PLASMAS

Bosnjakovic, F., et al.

RAND Corp., Santa Monica, California

Translation T-96, August 1958, (26 pp.)

(*ARS Journal,* Technical Literature Digest, p. 992, December 1959)

A translation of a German article presenting Mollier enthalpy-entropy diagrams for hydrogen and argon plasmas at temperatures up to 100,000°K and for pressures from 0.01 to 100 atm. The diagrams are shown with lines of constant pressure, density, temperature, and sonic velocity, and are further plotted in logarithmic coordinates to present the low-temperature region more clearly. Presented before the American Society of Mechanical Engineers at Purdue University, Lafayette, Indiana, February 23–26, 1959. (*RAND Index of Publications,* November, 1959.) (See also RAND T-99, and T-100.)

569. ON THE ELECTRON TEMPERATURE OF A PLASMA IN AN ALTERNATING ELECTRIC FIELD

Gurevich, A. V.

Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, v. 35, no. 2(8), pp. 392–400, 1958 (in Russian)

The heating of electrons in a plasma in an alternating electric field is considered. It is shown that electron gas can exist in two stable states with different temperatures; transition from one state to another occurs at certain critical values of the field amplitude and is accompanied by an appreciable change in the electron temperature. A peculiar type of hysteresis in the dependence of the electron temperature on the field of amplitude and frequency is observed. The influence of a constant magnetic field on

this effect is also taken into account. An expression was obtained for the complex conductivity of a plasma in an alternating electric and constant magnetic field (allowing for collisions between the electrons). (*PA*, 1959, #2446)

570. ON THE IONIZATION AND OHMIC HEATING OF A HELIUM PLASMA

Berger, J. M., et al.
***Physics of Fluids*, v. 1, no. 4, pp. 297–300, July–August, 1958**

A method which is used for the ionization and heating of helium plasmas in various stellarator models consists of inducing an approximately constant electric field along the main axial confining magnetic field. The details and results are presented of various calculations pertaining to this method. The gas is assumed initially to be 10 percent ionized and at a temperature of a few electron volts. The major approximations on which the calculations are based are: (1) Maxwellian velocity distributions for the particles, and (2) negligible charged particle loss across the confining magnetic field. The equations for the power balance and number balance were integrated in time numerically for a variety of initial conditions. The results indicate that temperatures of a few hundred electron volts are attainable within milliseconds with an applied field of the order 0.1 v/cm at densities of 3×10^{13} particles/cm^3. It was found that the maximum temperature is limited by power loss in bremsstrahlung radiation. (*PA*, 1959, #1555)

571. PLASMA HEATING OF HYPERSONIC GAS FLOW

Chuan, R. L.
University of Southern California, Engineering Center, Los Angeles
R56-202, December 1957 (19 pp.)
AFOSR TN 57-762
(ASTIA AD-136, 751)

For the production of condensation-free hypersonic flow in a wind tunnel it is proposed to add energy to the electrons in the air downstream of the throat by high-frequency electrodeless discharge, and allow electron energy to go into random kinetic energy of the molecules in the decay process. Previous work in this respect has dealt only with the discharge process, measuring the energy that can be added to the plasma by various types of discharges. The present work examines the decay processes in an attempt to channel as much of the electron energy as possible into raising the temperature of the gas, by preventing losses by ambipolar loss mechanism. Inhibition of ambipolar diffusion by means of an axial, constant magnetic field is examined, as well as the attendant possibility of having such an inhibiting effect nullified by drain diffusion resulting from hydromagnetic instability. An experimental investigation is being initiated. (*AMR*, 1959, #2658)

572. PLASMA HEATING OF SUPERSONIC AIRSTREAM

Chuan, R. L.
***Physics of Fluids* v. 1, no. 5, pp. 452, September–October, 1958**

Air molecules of Mach number 3.5 were shot through a region of 10 Mc electric field which caused partial ionization. Further downstream, the free electrons experience decay processes, so that energy they gained from the field was given to the molecules. Air temperatures of 900°C were obtained at 0.4 mm pressure. (*PA*, 1959, #1556)

573. PRELIMINARY RESULTS OF PLASMA HEATING OF HIGH SPEED AIR FLOW

Chuan, R. L.
University of Southern California, Engineering Center, Los Angeles
R56-203, July 31, 1958 (8 pp.)
AFOSR TN 58-650
(ASTIA AD-162, 182)

Presentation of preliminary experimental results from a simple model in which supersonic flow of nominal Mach Number 3.5 and Reynolds Number 2,000 (per cm) is heated by the decay of a plasma. The process of plasma heating and the experimental apparatus used are described. The maximum stagnation temperature attained is 934°C at a mass flow of 0.15 gm/sec, which represents a net heat input rate of about 100 watts. Inputs up to 300 watts have been achieved at higher mass flows and higher static pressures. (*A/SE*, 1958)

574. PRODUCTION OF HIGH TEMPERATURES AND NUCLEAR REACTIONS IN A GAS DISCHARGE

Thoneman, P. C., et al. (Atomic Energy Research Establishment, Harwell, England)
***Nature*, p. 217, January 25, 1958**

575. PROPULSION THROUGH HEATING AT SUPERSONIC SPEED
Oswatitsch, K. and Buecks, K. E.
Royal Aircraft Establishment, Great Britain
Translation 811, March 1959
(Translations-Germany)
Per-DVL-Bericht 90, Westdeutscher Verlag, Koeln v. Opladen, April 1959

Propulsion systems with air heating at supersonic speed can be envisaged if the heating process can be made possible. Good efficiency can however only be reached at very high Mach numbers. Compatibility conditions for the general case are given after the introduction of streamlines and their orthogonal trajectories as coordinates. These can be used in the computation of any arrangement for trailing edge heating.

576. SOME DYNAMICS PROBLEMS OF THE PUNCH METHOD OF HEATING AND ACCELERATION OF PLASMAS
Loos, H. G.
Plasmadyne Corp., Santa Ana, Calif.
AF 49[638]-355, R-T-2TNO29-335, February 1959
AFOSR TN-59-256
(ASTIA AD-212, 256)

A few dynamics problems encountered in punch discharges are discussed. The fully ionized plasma is supposed to interact with the magnetic field only at the plasma boundary. This analysis is limited to time intervals in which the effect of ion-ion collisions may be neglected. An introduction is given for the analysis of discharge dynamics for punch configurations with a general axisymmetric geometry.

577. THE GYRO-RELAXATION EFFECT
Schlüter, A.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 822–825, 1957 (in German)**

It is shown that, if the magnetic field changes with time or along the trajectories, a relaxation of the degrees of freedom of the motion along the lines of force occurs relative to those of gyration around these lines. The resulting increase in the temperature of a plasma may be used to attain very high temperature. (*PA*, 1959, #7113)

578. FAST ION HEATING
Reagan, D.
***Physical Review Letters*, v. 2, no. 3, pp. 82–83, February 1, 1959**

Transverse magnetic compression waves are invoked to account for part of the ion heating which occurs in "Zeta" and "Sceptre." An estimate is quoted of the magnitude of the energy available due to modes excited by the initial collapse of the discharge. The time required to give 100 ev energy to the ion is approximately 0.1 millisec. (*PA*, 1959, #5833)

579. THE "PUNCH" METHOD OF COMPRESSING, HEATING AND CONFINING OF A PLASMA
Loos, H. G.
Plasmadyne Corp., Santa Ana, California
TN T-ITN128-335, December 1958
AFOSR TN-58-1130 (25 pp. 10 ref.)
(ASTIA AD-207, 975)

(Abstracted in *Aero/Space Engineering*, May 1959)

580. THERMODYNAMICS FOUNDATION OF THE THEORY OF PLASMA
Kihara, T.
***Journal of the Physical Society of Japan*, pp. 128–133, February 1959**

(Abstracted in *Aero/Space Engineering*, May 1959)

581. UNIFIED DYNAMICS AND THERMODYNAMICS OF A THERMAL PLASMA
Maecker, H. and Peters, T.
RAND Corp., Santa Monica, California
Translation T-90, June 1958 (Translated from *Zeitschrift für Physik*, BD 144, pp. 586–611, 1956)
(*ARS Journal*, Technical Literature Digest, p. 992, December 1959)

582. 30,000 DEGREES WITH THE PLASMA JET
***Journal of Metals*, v. 11, no. 1, pp. 40–42, January 1959**

Expanding the frontiers of high-temperature, two U.S. firms recently have announced the development of plasma-type torches capable of producing a jet of electrically neutral, partially ionized gas at extremely high temperatures. The result is a radically new method for fabricating shapes and applying coatings that will withstand temperatures above 5000°F. (*AMR*, 1959, #3635)

CONFINEMENT

583. ON THE INERTIAL–ELECTROSTATIC CONFINEMENT OF A PLASMA
Elmore, W. C., Tuck, J. L., and Watson, K. M.
***Physics of Fluids*, v. 2, no. 3, pp. 239–246, May–June, 1959**

A system in which electrons are projected radially inwards from a spherical surface, was proposed for the confinement of a plasma at thermonuclear temperatures. The equilibrium, economics, and stability of such a system are discussed theoretically. Although it is concluded that it is of doubtful utility as a thermonuclear reactor, it may be possible to produce in this way small regions of thermonuclear plasma for study. The device appears to be unstable at economic densities. The stability is discussed in terms of a virial, which turns out to be mathematically tractable in this geometry. (*PA*, 1959, #8249)

584. ON THE CONFINEMENT OF PLASMA BY MAGNETOSTATIC FIELDS
Weibel, E. S.
***Physics of Fluids*, v. 2, no. 1, pp. 52–56, January–February, 1959**

The plasma is treated as an assembly of classical particles having masses $m+$ and $m-$ and charges $\pm e$. It is shown that if such a plasma is in thermodynamic equilibrium it is unaffected by a magnetostatic field. In particular, it cannot be confined by a magnetostatic field and at the same time be in equilibrium. In absence of collisions there exist stationary solutions for the magnetic field and the particle distribution in phase space such that the gas is confined. The solutions are self-consistent, meaning that the particle motions generate the field, which in turn maintains the particle distribution. However, this distribution may not be Maxwellian. As an example the linear pinch is treated. The fields, the particle number densities, and the current density are calculated for one particular case. (*PA*, 1959, #3600)

585. ON PLASMA COMPRESSION IN A MAGNETIC QUADRUPOLE FIELD
Christiansen, J.
***Zeitschrift für Naturforschung*, v. 13a, no. 11, pp. 951–961, November, 1958 (in German)**

The conditions in which charged particles are "compressed" along the axis of a stationary magnetic quadrupole field were studied. The ion paths were investigated, using h.f. excitation of the plasma, and approximate results obtained for the equilibrium density distribution of ions. A simple relation was found between apparent plasma column diameter, the central gas temperature and the magnetic flux density at the magnet surface. The theoretical results agree reasonably well with practice for weakly ionized gases. (*PA*, 1959, #5838)

586. NUCLEAR COMBUSTION PLASMAS AND MAGNETIC NUCLEAR COMBUSTION CHAMBERS FOR JET PROPULSION
Winterberg, F.
***Astronautica Acta*, v. 4, no. 4, pp. 235–263, 1958**

The properties of fusion and fission plasmas are discussed in connection with rocket propulsion. To prevent contact of the hot plasmas with the walls of the combustion chambers special arrangements of magnetic fields are proposed for confining the plasmas. For maintaining the necessary high magnetic fields a variety of methods for direct conversion of nuclear into electrical energy are considered. (*AMR*, 1959, #4731)

587. NEW CONFINEMENT PHENOMENA AND NEUTRON PRODUCTION IN A LINEAR STABILIZED PINCH
Burkhardt, L. C. and Lovberg, R. H.
***Nature*, p. 228, January 25, 1958**

A linear discharge device, designated Columbus S-4, has been constructed to test the effect of increased tube diameter and inter-electrode spacing on the properties of a B_z-stabilized pinched discharge. The apparatus utilizes the same capacitor bank as that employed in the magnetic probe experiments (75 μf, 20 kv) with the external

inductance reduced to 0.075 μh. The discharge tube is a cylinder of porcelain (Mullite) of inside diameter 5.0 in. and 24 in. spacing between electrodes. A close-fitting cylindrical return conductor of 1/16 in. stainless steel provides negligible delay in the 2-msec rise of the longitudinal (B_z) field which is set up by an external solenoid and capacitor bank. Provision has been made for radial insertion of a magnetic probe halfway between the electrodes.

588. MAGNETIC MEASUREMENT OF PLASMA CONFINEMENT IN A PARTIALLY STABILIZED LINEAR PINCH

Burkhardt, L. C., Lovberg, R. H., and Phillips, J. A.
***Nature*, p. 224, January 25, 1958**

The distribution of currents in a linear pinched discharge in deuterium has been measured by the use of small magnetic probes inserted into the plasma. This report of work performed in mid-1956 describes the current distribution in a discharge which compresses a longitudinal magnetic field originally set up in the tube by an external coil. The stabilizing properties of an included longitudinal field have been discussed theoretically elsewhere.

589. MAGNETICALLY CONFINED PLASMAS

Kolb, A. C.
***The Physical Review*, v. 112, no. 2, pp. 291–296, October 15, 1958**

Present paper describes the results of experiment on the shock preheating and the initial stages of compression of plasma, in both "T" and "H"-shaped shock tubes, subject to axial magnetic field induced by a series of single-turn coils.

It is found that the compression in "T"-shaped tube is about 1/8 of the tube radius and that the compressed plasma is remarkably stable. So far as stability is concerned, therefore, the configuration of currents and magnetic fields used in the present experiment is preferable to those encountered in the so-called "pinch effect" where there is high instability against lateral oscillations.

It seems that the present experiment will possibly become one of the starting points for the design of the controlled thermonuclear fusion reactors. (*AMR*, 1959, #4152)

590. EQUILIBRIUM OF A MAGNETICALLY CONFINED PLASMA IN A TOROID

Kruskal, M. D. and Kulsrud, R. M.
***Physics of Fluids*, v. 1, no. 4, pp. 265–274, July–August, 1958**

General properties of plasma in static equilibrium are derived from equations of magnetostatics. These properties are expressed as integrals over surfaces of constant pressures, which are shown to be topologically toroidal under general assumptions. A variational principle for such equilibrium conditions is derived. One of its consequences is characterization of equilibria by value of certain invariants. Conditions are then obtained for steady state of a plasma slowly diffusing across a magnetic field out of a topologically toroidal region. (*AMR*, 1959, #5257)

591. CONFINEMENT OF A PLASMA COLUMN BY RADIATION PRESSURE AND ITS APPLICATION TO FUSION POWER GENERATION

Weibel, E. S.
Ramo-Wooldridge Corp., Aeronautical Research Lab., Los Angeles, Calif.
R-ARL-57-1026, August 26, 1957

When assessing the value of a plasma confinement scheme three main requirements should be considered: the loss of plasma by diffusion, the stability of the configuration, and the power required for containment. In the present case of confinement by radiation pressure it was found that loss of plasma by diffusion is virtually absent. Two configurations have been investigated for stability. Both are unstable. However for the TM-mode there is just one deformation type which is not stable. It will be necessary to find means of stabilizing this deformation before radiation confinement becomes practical.

592. CONFINEMENT OF CHARGED PARTICLES BY A MAGNETIC FIELD

Lehnert, B.
***Nature*, v. 181, pp. 331–332, February 1, 1958**

A short note discussing confinement by axially symmetrical stationary magnetic fields and electric fields. A particular case is discussed, and a numerical example (deuterium at 10^8 °K, magnetic field 3×10^5 gauss, coil radius 5 m) is taken. (*PA*, 1958, #4042)

593. A RADIO FREQUENCY DEVICE FOR PLASMA CONTAINMENT
Josephson, V.
Space Technology Laboratories, Physical Research Lab., Los Angeles, Calif.
R-GM-TR-0165-00555, December 31, 1958
AF 04(647)-165

A design study has been made on an experimental assembly which develops a DC B_θ −RF B_z magnetic field configuration around toroidal plasma column with B_z B_θ. This combination has been found theoretically stable by Weibel. It appears that a hot ($\sim 10^6$ degree) plasma column of 10^{14} particles/cc density can be generated in such a configuration and contain for $\sim 100\mu$ sec by Klystron generation of ~6MW of RF B_z power around the column. Details of the design and assembly are given and possible experimental and design pitfalls are discussed.

594. A NOTE ON THE CONFINEMENT OF A PLASMA BY R. F. FIELDS
Weibel, E. S.
***Journal of Electronics and Control*, v. 5, no. 5, pp. 435–438, November 1958**

Similar results have been reached by different methods by Boot, et al. (*PA*, #5069) and by Weibel, ("The Plasma in a Magnetic Field", Papers of the Magnetohydrodynamics Symposium December 1957, Palo Alto, Stanford University Press, 1958, pp. 60–76). Assumptions and approximations in the former derivation are criticized, and the difficulties of plasma confinement emphasized. (*PA*, 1959, #3595)

595. THE CONTAINMENT OF PLASMA BY THE PINCH DISCHARGE
Thomson, G.
***The Philosophical Magazine*, Eighth Series, v. 3, pp. 886–896, August, 1958**

When a strong current is flowing axially in a plasma, with cylindrical geometry, the charged particles of the plasma will be prevented from striking the cylindrical wall both by the self-magnetic field of the current and, in the case of the positive ions, by the electric field due to the negative charge in the region of the current. Calculations are made of these effects, which are relevant to the loss of heat by conduction from a thermonuclear device of the Zeta type. It is shown that in order to reduce the loss of heat by conduction to a value less than the energy generated in the discharge by a thermonuclear reaction in deuterium, it is necessary either to have a magnetic field corresponding to a current of the order of a thousand million amps, or to have a substantial electric field, giving a radial potential difference between the axis and wall of the order of 250-500 kv, together with currents of a few million amps. Reasons are given for supposing that such an electric field would in fact be set up as a concomitant of the current and the reaction. (*PA*, 1959, #1548)

PINCH EFFECT

596. ELECTROMECHANICAL ENERGY CONVERSIONS IN A CYLINDRICAL PINCH PROCESS
Neuringer, J. L.
***IRE Transactions on Space Electronics and Telemetry*, v. Set-5, no. 2, pp. 55–56, June 1959**

597. INVERSE PINCH EFFECT
Anderson, O. A., et al.
***Physics of Fluids*, v. 1, no. 6, pp. 489–494, November–December, 1958**

An electric current passing along a conducting rod and returning through ionized gas surrounding the rod forms a magnetic field pushing the plasma outward, leaving behind a cylindrical vacuum region. This effect appears to be more amenable to experimental studies than is the pinch effect.

Displacement and thickness of the plasma front were measured optically and magnetically. At low mass densities, the observed front thickness justifies use of the "snowplow" model, and the front velocity is described to good approximation by analytical results based on this model. At higher densities, it appears that the magnetic field is diffused significantly into the cold plasma.

Authors' suggestion that these studies of the inverse dynamic pinch be followed by studies of the inverse stabilized pinch seems to merit consideration. (*AMR*, 1959, #6334)

598. NEUTRONS FROM A STABILIZED TOROIDAL PINCH
Honsaker, J., Karr, H., et al.
***Nature*, p. 231, January 25, 1958**

599. NEUTRON PRODUCTION IN A HIGH-POWER PINCH APPARATUS
Hagerman, D. C. and Mather, J. W.
***Nature*, p. 226, January 25, 1958**

In the work on fusion power devices, several investigators have studied the neutrons produced by forming a pinch in deuterium. This communication reports on those neutrons coming from the Los Alamos Scientific Laboratory device known as Columbus II (July 1957). In view of the fast rate of growth of instability amplitudes in the pinch, Columbus II was designed as a high-powered machine in which the current reached its maximum value in as short a time as possible.

600. NEUTRON GENERATION FROM STRAIGHT PINCHES
Dunway, R. E. and Phillips, J. A.
***Journal of Applied Physics*, v. 29, no. 8, pp. 1137–1143, August 1958**

Experiments on the neutrons produced in deuterium gas during a high-current pulsed discharge are described. With 15 kv applied to a straight discharge tube 30 cm long, neutrons are produced during a 0.1 μsec pulse ~1.4 μsec after gas breakdown. The yield of 10^7 to 10^8 neutrons per discharge depends on gas purity and the discharge tube wall material. The axial asymmetry in neutron energy indicates that the neutrons are produced in reactions whose center of mass moves preferentially towards the cathode. (*PA*, 1959, #533)

601. OBSERVATIONS OF THE PINCH EFFECT AT DECREASING CURRENTS
Granovskii, V., P. et al.
***Soviet Physics–JETP*, v. 8, no. 1, pp. 33–36, January 1959 (Translation of *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, Akademii Nauk SSSR*, v. 35, pp. 45–50, July, 1958 by American Institute of Physics, Inc., New York, N. Y.)**

Image-converter photographs have been taken of transient states of pulsed discharges in H_2 and Hg at pressures of 10^{-2} to 10^{-3}mm Hg. The peak pulse currents were 1.3 to 5.5 kiloamperes and the pulses were 300 μsec long. Elec-

trodynamic deformations (contraction and kinking) are observed at negative values of di/dt. It is found that these deformation effects first disappear (as manifested by the straightening and expansion of the column) at points of high local gas density (anode or cathode depending on the experimental conditions). (*AMR*, 1959, #6332)

602. PINCHED DISCHARGE AND THERMONUCLEAR REACTOR
Gardner, J. W.
***Il Nuovo Cimento*, v. 6, p. 1228, 1957**

Perturbation theory approach to theoretical analysis of pinch kink instability.

603. RAPID COMPRESSION OF A PLASMA WITH AZIMUTHAL CURRENTS
Niblett, G. B. F.
***Proceedings of the Institution of Electrical Engineers*, (Convention on Thermonuclear Processes) Paper 2882, April 1959 (6 pp.)**
To be republished in Vol. 106A, 1959

Discusses a rapid pinch process in which azimuthal currents and their associated axial magnetic fields are used to heat and confine a plasma. A simple one-dimensional model of the fast pinch process is used to show how the temperature attained by the plasma depends upon the discharge parameters and in particular that the energy per particle is proportional to the electric field developed across the plasma surface. Previous work on this form of pinch effect is reviewed and an account is given of preliminary experiments at the Atomic Weapons Research Establishment (A.W.R.E.). The principal features of a toroidal system using azimuthal currents and axial fields to heat and subsequently confine a plasma is presented and the advantages and consequences of this configuration are examined, particularly as compared with a torus using axial currents. After the initial rapid heating process the plasma and magnetic field diffuse into each other and the configuration is similar to that in the Stellarator, with similar stability problems and similar possibilities of continuous operation. (*PA*, 1959, #4736)

604. THE ELECTROMAGNETIC PINCH EFFECT FOR SPACE PROPULSION
Kunen, A. E. and McIllroy, W.
American Rocket Society, New York, N. Y.
P-908-59, August 24–26, 1959
August 24–26, 1959

The phenomenon of the electromagnetic pinch effect is used to accelerate ionized gases for space propulsion. Electrical energy, initially stored in capacitors, is discharged across two nozzle shaped electrodes wherein the radial pinch is converted to axial motion of the effected gases instead of confinement at the axis. Experiments on three different electrode designs are discussed and the results obtained are compared with the calculated values. The results of the study are applied to one particular space propulsion system consisting of a nuclear energy source, a space radiator, a turbine-generator, capacitor, and a pinch tube.

605. THE MAXIMUM DISTURBANCE GROWTH RATE FOR AN UNSTABLE PLASMA COLUMN
Kaneko, S.
***Journal of the Physical Society of Japan*, v. 13, no. 8, pp. 947–953, August 1958**

A dispersion relation for a self-pinched plasma column enclosed by a conducting wall is derived for the case of a model with both surface sheet current and uniform volume current. On the basis of this dispersion relation, the maximum disturbance growth-rate for the instability is calculated. Both the uniform volume current and longitudinal magnetic flux outside the plasma column decrease the stability and make the growth-rate faster, the effect of the magnetic flux being larger. (*PA*, 1959, #357)

606. THE PINCH EFFECT
Cole, G. H. A.
***Science Progress*, v. 47, pp. 437–458, July, 1959**

A general review, with 53 references. There are, for example, sections on current distributions, the effect of longitudinal magnetic fields, the dynamic pinch in the absence of a magnetic field, the snow plough model, the shock wave model, the dynamic pinch, trapped magnetic field and pinch stability. (*PA*, 1959, #12407)

607. THE SCALING LAWS FOR THE STABILIZED PINCH
Bickerton, R. J. and London, H.

Proceedings of the Physical Society, London, v. 72, p. 116, 1958

608. **THE SUPER-FAST LONGITUDINAL PINCH**
Fried, B. D.
Ramo-Wooldridge Corp., Aeronautical Research Laboratory, Los Angeles, Calif.
R-ARL-7-60, November 12, 1957, AF 04(647)-127

The superfast non-adiabatic pinch is a promising method of heating a plasma without violating the conditions necessary for subsequent confinement with a stabilized pinch. An experimental test of the feasibility of a superfast longitudinal pinch at high density is currently in progress. The ideas underlying this concept are reviewed and a simple theoretical model is used for calculations of the results to be expected from these experiments.

VORTEX

609. SIMPLE VORTICITY LAWS IN MAGNETOHYDRODYNAMICS
Wu, C.-S.
Princeton University, Department of Aeronautical Engineering, New Jersey
Report 445, November 1958, AFOSR TN 58-1044 (ASTIA AD-206, 756)

Derivation of simple vorticity laws in magnetohydrodynamics. The analysis includes the generalized Crocco's vorticity law and Lighthill's expression for vorticity behind a three-dimensional shock wave. No consideration is given to microscopic phenomena of an ionized gas. A generalization of Hayes derivation of vorticity jump across a gas dynamic discontinuity is also obtained. (*A/SE*, 1959)

610. ON CIRCULAR CYLINDRICAL VORTICES IN MAGNETOHYDRODYNAMICS
Zeuli, T.
***Atti dell' Accademia delle Scienze di Torino*, v. 92, no. 1, pp. 105–114, 1957–1958 (in Italian)**

Expressions are derived for fluid pressure and velocity, and for the magnetic field intensity, in the case of an axially symmetric vortex of finite radius at rest in a uniform conducting liquid of unlimited extent, the magnetic field being parallel to the axis of the vortex. (*PA*, 1958, #8148)

611. RING VORTICES GENERATED ELECTROMAGNETICALLY
Yih, C.-S.
***Journal of Fluid Mechanics*, pp. 436–444, April 1959**

Study showing that Taylor vortices occur in a fluid between concentric cylinders if a longitudinal electric current passes along the axis of the cylinders and another passes through the fluid. Specific results are given for small differences in radii. The cause of the instability is the centripetal electromagnetic body force acting on the fluid in the undisturbed state. (*A/SE*, June 1959)

612. ON THE DISTURBED MOTION OF A PLANE VORTEX SHEET
Miles, J. W.
***Journal of Fluid Mechanics*, pp. 538–552, September 1958 (10 ref.)**

Development of a formal solution to the initial value problem for a plane vortex sheet in an inviscid fluid by transform methods. The eigenvalue problem is investigated and the stability criterion determined. Results confirm those of Landau, Hatanaka, and Pai with respect to stability, but rule out certain of their neutral eigenvalues. The fact that supersonic disturbances may be unstable is established. An asymptotic approximation is developed for the displacement of a vortex sheet following a suddenly imposed, spatially periodic velocity. (*A/SE*, December 1958)

613. AN ANNULAR MAGNETO-VORTEX
Shafranov, V. D.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 33, no. 3(9), pp. 831–382, 1957 (in Russian)**

A solution has been found of the hydromagnetic equations for an annular vortex system with axial symmetry. (*PA*, 1958, #2427)

614. MAGNETO-VORTEX RINGS
Shafranov, V. D.
***Soviet Physics–JETP*, v. 6, p. 624, 1958**

615. ON HELICOIDAL VORTICES IN MAGNETOHYDRODYNAMICS
Vacca, M. T.
***Atti dell' Accademia delle Scienze di Torino*, pp. 551–562, 1957–1958 (in Italian)**

A solution of the equations of motion for an unbounded conducting liquid in the presence of a uniform magnetic field defines a cylindrical vortex in which the vortex lines are coaxial circular helices whose axis is parallel to the

applied magnetic field. Expressions are derived for velocities and field intensities inside and outside the vortex. (*PA*, 1959, #3653)

616. THE VORTEX EQUATIONS OF MAGNETOHYDRODYNAMICS

Brinkman, H. C.

***Physica*, v. 25, no. 11, p. 1063, November 1959**

The vortex equations of magnetohydrodynamics are derived. Three vortices, viz., a material, an electrical and a magnetic vorticity are introduced. In their integral form, i.e., as equations for material and the electrical circulation, the equations are applied to a rotating plasma in a thermonuclear device.

617. SPHERICAL VORTEX IN MAGNETO-HYDRODYNAMICS

Agostinelli, C.

***Atti dell' Accademia Nazionale dei Lincei*, v. 24, pp. 35–42, January 1958 (in Italian)**

The possible formation of a spherical vortex in a perfect electroconducting fluid from the generation of a magnetic field is studied. It is shown that if the fluid has infinite conductivity and is subject to a uniform magnetic field with fixed direction, the formation of a spherical vortex, symmetric with respect to the direction of the magnetic field, is possible. The kinetic characteristics of the vortex coincide with those of the Hill vortex. The center of the vortex moves with a uniform linear motion according to the axis of the imposed magnetic field. It generates, in its turn, a magnetic field whose components appear continuously through the spherical surface of the vortex. At infinity the velocity approaches zero, the pressure tends toward a finite value, and the magnetic field nears a constant value. (*NSA*, 1959, #5873)

STABILITY (DIVERSIFIED)

618. THE STABILITY OF THE PINCH. APPENDIX—THE PROPAGATION OF PLANE HYDROMAGNETIC WAVES IN AN INFINITE MEDIUM
Chandrasekhar, S., Kaufman, A. N., and Watson, K. M.
***Proceedings of the Royal Society of London,* Series A, pp. 435-455, July 8, 1958**

Investigation on the stability of a cylindrical plasma with an axial magnetic field and confined between conducting walls by solving, for small oscillations about equilibrium, the linearized Boltzmann and Maxwell equations. A criterion for marginal stability is derived; this differs slightly from the one derived by Rosenbluth from an analysis of the particle orbits. However, Rosenbluth's principal results on the possibility of stabilizing the pinch under suitable external conditions are confirmed. In addition a dispersion relation is derived which discloses under the simplest conditions certain types of instabilities which may occur in plasma physics. (*A/SE*, September 1958)

619. A PROPOSED METHOD FOR THE ANALYSIS OF THE STABILITY OF HIGHLY SYMMETRIC HYDROMAGNETIC EQUILIBRIA VIA THE BOLTZMANN EQUATION
Bernstein, I. B.
Princeton University, New Jersey
Project Matterhorn, (AT[30-1]-1238) TM 57, NYO-7996, November 20, 1957

A method is presented which in principle permits the investigation of the stability of hydromagnetic equilibria via the Boltzmann equation in the limit of negligible collisions. It is applicable only to certain highly symmetric situations, namely slab and cylinder symmetry, but where applicable it does not require any assumptions of quasi-neutrality, adiabaticity, etc., which are common to the familiar hydromagnetic treatments of the problem. The technique is an extension to the problem of small motions about an equilibrium configuration of a method for the determination of self-consistent equilibria. It consists in employing as coordinates in the Boltzmann equation quantities which are constants of the motion in the equilibrium. (*NSA*, 1959, #4813)

620. AN ENERGY PRINCIPLE FOR HYDROMAGNETIC STABILITY PROBLEMS
Bernstein, I. B., et al.
***Proceedings of the Royal Society of London,* Series A, v. 244, no. 1236, pp. 17–40, February 1958**

Stability problem of static, highly conducting, fully ionized plasmas is investigated by means of an energy principle. The conditions under which it applies are given. Method is applied to find complete stability criteria for two types of equilibrium situations. The first concerns plasmas which are completely separated from magnetic field by an interface. Second is a general axisymmetric system. (*AMR*, 1959, #471)

621. A NOTE ON HYDRODYNAMIC STABILITY IN UNLIMITED FIELDS OF VISCOUS FLOW
Curle, N.
Aeronautical Research Council, Great Britain
R-F.M. 2314, R-17,953, October 21, 1955

The boundary conditions derived by McKoen for oscillations of jet and wake-type flows is obtained by an approach valid for symmetrical and anti-symmetrical oscillations. A continuous expression for the viscous integral Φ is obtained; but Φ' has a discontinuous singularity which requires the examination of the modifications near to the singular point.

622. BOUNDARY-LAYER STABILITY DIAGRAMS FOR ELECTRICALLY CONDUCTING FLUIDS IN THE PRESENCE OF A MAGNETIC FIELD
Rossow, V. J.
National Advisory Committee for Aeronautics, Washington, D.C.
NACA TN 4282, August 1958

Neutral stability curves pertaining to a two-dimensional infinitesimal sinusoidal disturbance are presented for the

laminar flow of an incompressible, electrically conducting fluid over a semi-infinite flat plate in the presence of either a coplanar or transverse magnetic field. The magnetic field is found to be stabilizing in all of the cases studied except one.

623. DYNAMIC STABILITY OF A SELF-PINCH DISCHARGE

Wyld, H. W., Jr.
***Journal of Applied Physics*, pp. 1,460–1,465, October 1958**

Study of the stability of a rapidly contracting self-pinched discharge using three different models for the plasma dynamics: the free particle model, the snowplow model, and the shock wave model. For each model the growth in time of a small perturbation on a time-dependent unperturbed solution of the equations of motion is obtained. It is shown that the free particle model and the shock wave model predict instabilities, and that an initially small perturbation becomes large in time comparable to the pinch time. The snowplow model predicts stability for the initial stages of the pinch, although instabilities probably develop later on. (*A/SE*, December, 1958)

624. EXPERIMENTS ON THE INSTABILITY OF A LAYER OF MERCURY HEATED FROM BELOW AND SUBJECT TO THE SIMULTANEOUS ACTION OF A MAGNETIC FIELD AND ROTATION

Nakagawa, Y.
***Journal of Royal Society of London*, v. 242, no. 1228, pp. 81–88, October 1957**

A pool of mercury placed in a Pyrex glass container was heated electrically from below and was rotated in the magnetic field of cyclotron magnet. Thermocouple readings were made but no flow measurements were taken. Results are compared with Chandrasekhar's theoretical predictions. (*AMR*, 1958, #2172)

625. HYDROMAGNETIC EFFECTS UNDER CONDITIONS OF LOCALIZED THERMAL INSTABILITY

Levengood, W. C.
***The Astrophysical Journal*, p. 483, March 1959**

Thermal convection experiments were conducted in an attempt to explain previously observed hydromagnetic effects in silver patterns deposited on glass. Convective regions were produced in alcohol and alcohol-powder mixtures by locally heating with the poles of permanent magnets. Optical and weight-difference techniques were developed to compare observed differences in the convection process over the pole regions of the magnet. These phenomena suggested electric charge effects within the liquid, and the results were found to agree with the basic electrodynamics of charges moving in a magnetic field. These force effects on charged particles also provided an explanation for the observed differences in the silver-deposit patterns. The Earth's magnetic field was found to have an effect on the localized convection process. The difference over the pole regions was most pronounced when the magnet poles were aligned in the same position as the geomagnetic poles of the Earth.

626. HYDROMAGNETIC EQUILIBRIUM. II. STABILITY IN THE VARIATIONAL FORMULATION

Woltjer, L.
***Proceedings of the National Academy of Sciences of the U. S.*, v. 45, pp. 769–771, June 1959**

Two points in an earlier paper are clarified: the set of integrals offered previously was not complete; and an incorrect statement concerning the stability of equilibria was made. (*NSA*, 1959, #16363)

627. HYDROMAGNETIC INSTABILITIES OF A CYLINDRICAL GAS DISCHARGE II: INFLUENCE OF VISCOSITY

Tayler, R. J.
Atomic Energy Research Establishment, Harwell, England
AERE TIR 1888, 1958
(*ARS Journal*, Technical Literature Digest, p. 886, November 1959)

628. ON THE STABILITY OF A HYDROMAGNETIC PROMINENCE MODEL

Brown, A.
***The Astrophysical Journal*, p. 646, July–November 1958**

The prominence material is treated as a compressible, inviscid fluid of high conductivity which is in static equi-

librium under the usual hydromagnetic forces. For simplicity, a two-dimensional model is used. The equilibrium problem is shown to depend on a single partial-differential equation, and this is used to relate the solutions of the equilibrium problem proposed by different authors. The stability of one of these solutions is discussed in detail. A variational method is used to examine the characteristic value problem which arises when the equilibrium configuration is perturbed. It is found that the equilibrium solution is stable for vertical displacements and probably stable for horizontal displacements also, although in the latter case the results depend on the values of two parameters, and computations were carried out for only a selection of values of these parameters. The paper concludes with a discussion of the applicability of the solution concerned to observed types of prominence.

629. HYDROMAGNETIC STABILITY OF A CONDUCTING INVISCID INCOMPRESSIBLE FLUID OF VARIABLE DENSITY
Talwar, S. P.
***Zeitschrift für Astrophysik*, Germany, v. 47, no. 3, pp. 161–168, 1959**

(Abstracted in *Bulletin Signaletique, Section IIA, Astronome-Astrophysique*, v. 20, no. 11–12, p. 5260, 1959)

630. HYDROMAGNETIC STABILITY OF A CONDUCTING FLUID IN A CIRCULAR MAGNETIC FIELD
Edmonds, F. N., Jr.
***Physics of Fluids*, v. 1, no. 1, pp. 30–41, January–February, 1958**

The theory of viscous flow between two rotating coaxial cylinders as developed by Taylor and Chandrasekhar is extended to the case when the fluid is an electrical conductor and a circular magnetic field (i.e., one whose lines of force are concentric with the cylinder walls) is present. The equations governing marginal stability are derived, and boundary conditions for perfectly conducting cylinders (Fermi boundary conditions) are formulated for two cases when the difference in cylinder radii is small compared with their mean. In the first case, co-rotating cylinders, the underlying characteristic value problem is solved by a variational method developed by Chandrasekhar to show that convective instability rather than oscillatory overstability will occur for realizable magnetic field strengths. In the second case, co-rotating and counter-rotating cylinders, the underlying characteristic value problem is solved by an expansion in orthogonal functions method developed by Chandrasekhar to determine critical Taylor numbers for marginal stability. The magnetic field inhibits the onset of instability, but this effect is quite small as the hydromagnetic interaction involves displacement but not distortion of the magnetic lines of force. (*PA*, 1958, #6070)

631. THE INSTABILITIES OF A CYLINDRICAL GAS DISCHARGE WITH FIELD PENETRATION
Hubbard, J.
Atomic Energy Research Establishment, Harwell
T/R2668, 1958

Describes a calculation of the stability with field penetration, in which the effects of finite conductivity and viscosity are approximately taken into account. A wide range of field configurations was investigated. (*PA*, 1959, #3593)

632. MAGNETOGRAVITATIONAL INSTABILITY OF AN INFINITE CYLINDER
Dibai, E. A.
***Astronomicheskii Zhurnal*, v. 35, no. 2, pp. 253–256, 1958 (in Russian)**

In a previous paper (*Astronomicheskii Zhurnal*, v. 32, pp. 954–956, 1957) a study was made of the instability of a compressible fluid cylinder with respect to longitudinal vibrations. This treatment is now generalized by taking into account the electromagnetic, as well as the gravitational, field. It is shown that the gravitational instability of an infinite gaseous cylinder with respect to longitudinal oscillations is independent of the presence of an electromagnetic field directed along its axis, and the criterion of gravitational instability is the same whether the field is present or not. The theory is used to investigate the stability of five globules formed as a result of the breaking up of a dark filament in Taurus. The densities and masses of these globules are probably sufficient for the formation of stars from them by gravitational condensation. (*PA*, 1958, #7198)

633. ON MAGNETOHYDRODYNAMICAL EQUILIBRIUM CONFIGURATIONS. APPENDIX—CRITERIA FOR THE STABILITY OF A PERFECTLY CONDUCTING CYLINDER WITH A SURFACE CURRENT
Shafranov, V. D.

Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, pp. 710–722, September, 1957 (Translation in *Soviet Physics–JETP*, pp. 545–554, March, 1958, 15 ref.)

Investigation of the equilibrium conditions for bounded systems of a conducting gas in a magnetic field. The equilibrium conditions for a gravitating ring with current embedded in a gaseous atmosphere, and for a ring in an external magnetic field are considered. A theorem is formulated showing the analogy between the magnetohydrodynamical equilibrium systems and the hydrodynamical vortices. The problem of the equilibrium conditions for magnetohydrodynamical configurations is reduced to the theory of stationary flow of an incompressible fluid by this theorem. General equilibrium conditions for an axially symmetric system are considered. (*A/SE*, 1958)

634. ON THE HYDRODYNAMIC STABILITY OF CURVED LAMINAR COMPRESSIBLE FLOWS

Lessen, M.
Institute of the Aeronautical Sciences, Inc., N.Y.
Preprint 812, January 1958
(*Jet Propulsion*, Technical Literature Digest, 1958)

635. ON THE STABILITY OF A PLASMA

Hain, K., et al.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 833–841, 1957 (in German)**

It is shown that, neglecting viscosity, resistivity and thermal conductivity, motion in the neighborhood of equilibrium is governed by a self-adjoint differential equation of the second order. Some general theorems are established and some sufficient conditions for stability are given. (*PA*, 1959, #1607)

636. ON THE STABILITY OF PLASMA IN STATIC EQUILIBRIUM

Kruskal, M. D. and Oberman, C. R.
***Physics of Fluids*, v. 1, no. 4, pp. 275–280, July–August, 1958**

Criteria for stability of a system of charged particles are derived from Boltzmann equation in small m/e limit. These criteria are obtained from examination of variation of energy due to a perturbation subject to constraint that all time-independence constants of motion have their equilibrium values. Authors find that first-order variation of energy vanishes, while second-order variation yields quadratic form in displacement variable. Positive definiteness of form is sufficient condition for stability. Authors also state theorem comparing their stability criterion with that of conventional hydromagnetic theory where heat flow along magnetic lines has been neglected. (*AMR*, 1959, #5258)

637. ON THE STABILITY OF SHOCK WAVES IN MAGNETOHYDRODYNAMICS

Akhiezer, A. I.,Lyubarskii, G.Y., and Polovin, R. V.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, pp. 731–737, 1958 (in Russian) Institute of Physics and Technology, Academy of Sciences Ukrainian SSR**

The regions of nonstability of a stationary magnetohydrodynamical shock wave with respect to one-dimensional perturbations were determined. It is shown that two types of stable shock waves exist. The types of shock waves which can follow each other are ascertained. (*NSA*, 1959, #1540)

638. ON THE STABILITY OF SHOCK WAVES IN MAGNETOHYDRODYNAMICS

Syrovatskii, S. I.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, pp. 1457–1470, December 1958 (in Russian). Lebedev Institute of Physics, Academy of Sciences, USSR**

The interaction between shock waves in a magnetic field and magnetohydrodynamic waves of small amplitude are considered. The condition for stability with respect to spontaneous emission of weak magnetohydrodynamical waves by a shock wave were obtained. Conditions under which the linear equations for a small perturbation do not have a solution were found, this case being interpreted as a disintegration of a shock wave. (*NSA*, 1959, #4912)

639. RING VORTICES GENERATED ELECTROMAGNETICALLY

Yih, C. S.
***Journal of Fluid Mechanics*, v. 5, no. 3, pp. 436–444, April 1959**

If an electric current of uniform density j_0 is passed axially through a stationary fluid between concentric cyl-

inders of radii r_1 and $r_2(>r_1)$, the fluid is stable to axisymmetric disturbances only if damping provided by viscosity and electrical resistivity is sufficiently large. It is shown that the fluid may also be stabilized by passing a line current J along the axis, sufficient condition for stability being $j\leq -\pi j_0(r_2^2-r_1^2)$ or $\geqslant j\pi j_0 r_1^2$. The values of J needed to stabilize the fluid for non-zero viscosity and finite conductivity are calculated for the case $r_2-r_1\ll r_1$. In this latter case, the ring vortices which exist under conditions of neutral stability are exactly the same as those for flow between rotating cylinders if J and j_0 have the same sign and if J is not very small compared with $\pi j_0 r^2$. (*AMR*, 1959, #6327)

640. SOME STABLE HYDROMAGNETIC EQUILIBRIA

Johnson, J. L., et al.
***Physics of Fluids*, v. 1, no. 4, pp. 281–296, July–August 1958**

Authors obtain hydromagnetic equilibria for a variety of situations which have approximately zero pressure uniform axial magnetic field. Criteria for ascertaining the stability of these equilibria are derived by means of energy principle. In particular, if helically invariant fields are present, stable equilibria with non-zero pressure and net axial current can be found. (*AMR*, 1959, #5259)

641. INVESTIGATION OF THE STABILITY OF A GRAVITATING PLASMA IN CROSSED MAGNETIC FIELDS

Meyer, F.
***Zeitschrift für Naturforschung*, v. 13a, no. 12, pp. 1016–1020, December 1958 (in German)**

A plasma with an interior horizontal magnetic field is supported against gravity by a horizontal vacuum field inclined to the interior field at an angle α. This angle can be adjusted so that equilibrium is stable with respect to disturbances of small wavelength; in particular, the Kruskal-Schwarzschild instability for the case $\alpha=0$ (*PA*, 1954, #6324) can be removed by a suitable choice of α. Equilibrium is unstable with respect to disturbances of long wavelength. (*PA*, 1959, #4840)

642. STABILITY OF AXIALLY SYMMETRICAL PLASMA CONFIGURATION IN VOLUME FLOW

Hain, K. and Lüst, R.
***Zeitschrift für Naturforschung*, v. 13a, no. 11, pp. 936–940, November 1958 (in German)**

Small perturbation techniques are used to investigate plasma configurations containing currents inside the plasma and possessing cylindrical symmetry. The problem is reduced to an eigen-value problem. Considering a special configuration with a relatively strong current along the axis, it is shown that this configuration is unstable for long wavelength perturbations. (*AMR*, 1959, #6337)

643. STABILITY OF HYDROMAGNETIC EQUILIBRIA WITH HELICALLY INVARIANT FIELDS

Johnson, J. L., et al.
Princeton University, New Jersey
Project Matterhorn (AT[30-1]-1238) PM-S-34, NYO-7904, August 1, 1957

An equilibrium situation is obtained for the case of a uniform axial magnetic field with the addition of a superposition of weak helically invariant fields, a field due to a small axial current, and a field due to a low-pressure infinitely conducting plasma. The energy principle is used to determine conditions for the stability of this equilibrium. Two basic results are obtained: (a) the conditions for the stability of a system which consists of a superposition of helical fields and "bulge" fields ($l=0$) are determined; and (b) it is shown that the addition of a helical field with $l=3$ can produce complete hydromagnetic stability when an axial current is flowing and can also increase the Kruskal limit on the current for the $m=1$ mode. (*NSA*, 1959, #5352)

644. STABILITY OF THE STATIONARY CONVECTIVE FLOW OF AN ELECTRICALLY CONDUCTING LIQUID BETWEEN PARALLEL VERTICAL PLATES IN A MAGNETIC FIELD

Gershuni, G. Z. and Zhukhovitskii, E. M.
***Soviet Physics–JETP*, v. 7, no. 3, pp. 465–470, September 1958 (Translation of *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, Akademii Nauk SSSR*, v. 34, no. 3, pp. 670–674, March 1958 by American Institute of Physics, Inc., New York, N. Y.)**

Small time-dependent perturbation quantities are introduced in the hydrodynamic, heat-transfer and magnetic

field equations. The stability of a free convective flow between two vertical parallel plates at different temperatures with a magnetic field perpendicular to the plates is investigated. The study shows that the stability of the steady flow is increased greatly by the presence of the magnetic field. The stability for the case when the applied magnetic field is parallel to the walls is also discussed. Critical values of Grashof and wave number are presented as a function of the Hartmann number for the transverse and longitudinal magnetic field cases. (*AMR*, 1959, #4155)

645. STABILIZATION OF A PINCH BY AN ALTERNATING MAGNETIC FIELD
Weibel, E. S.
Space Technology Laboratories, Physical Research Laboratory, Los Angeles, Calif.
Ramo-Wooldridge Corp.
AF 04(647)-127, R-GM-TR-0127-00399, June 4, 1958

The idea of stabilizing a magnetically confined plasma by oscillating fields has been proposed very recently, but without definite results. Since the system plasma-field is one of an infinite number of degrees of freedom a single Mathieu equation cannot describe it. Instead an infinite system of coupled differential equations with periodic coefficients is obtained. So far, no progress towards establishing an exact stability criterion based on these equations has been made, however this paper describes what is hoped to be a first step towards the solution of the problem.

646. THE EFFECT OF FLUID MOTIONS ON THE STABILITY OF TWISTED MAGNETIC FIELDS
Trehan, S. K.
***The Astrophysical Journal*, p. 475, March 1959**

The stability of twisted magnetic fields confined to an infinitely long cylinder of incompressible inviscid fluid of infinite electrical conductivity is investigated when fluid motions of varying amounts are present along the lines of force. It is found that the system is stable only when the energy in the velocity field is at least equal to that in the magnetic field.

647. THE EQUILIBRIUM OF A SELF-GRAVITATING INCOMPRESSIBLE FLUID SPHERE WITH A MAGNETIC FIELD. II.
Pendergast, K. H.
***The Astrophysical Journal*, v. 128, no. 2, pp. 361–374, September 1958**

An equilibrium model (descibed in a previous series paper) is shown to be dynamically unstable if the magnetic energy exceeds two-fifths of the gravitational energy.

648. THE INFLUENCE OF A MAGNETIC FIELD ON THE LONGITUDINAL STABILITY OF A GRAVITATING CYLINDER
Auluck, F. C. and Kothari, D. S.
***Zeitschrift für Astrophysik*, v. 42, no. 2, pp. 101–113, 1957**

The paper deals with the problem of the longitudinal stability of an infinitely long gravitating cylinder subject to the influence of a magnetic field; the material is assumed to be incompressible, inviscid and infinitely conducting. The cases of current-distribution inside the cylinder giving poloidal and toroidal fields are considered. The case of a uniform field (H_1) inside the cylinder and a uniform field (H_2) outside it is also described. The general conclusion is that in every case the magnetic field increases the stability of the cylinder. (*PA*, 1959, #5959)

649. THE INSTABILITY OF A LAYER OF [AN ELECTRICALLY CONDUCTING] FLUID HEATED BELOW AND SUBJECT TO THE SIMULTANEOUS ACTION OF A MAGNETIC FIELD AND ROTATION [CORIOLIS ACCELERATION]
Namikawa, T.
***Journal of Geomagnetism and Geoelectricity*, v. 8, no. 2, pp. 81–85, June 1956**
(*Physics Abstracts*, January 1959, #469)

650. THE INSTABILITY OF A PINCHED FLUID WITH A LONGITUDINAL MAGNETIC FIELD
Kruskal, M.
***Proceedings of the Royal Society of London*, Series A, pp. 222–237, June 3, 1958**

Analysis of the stability of a pinched plasma equilibrium with a longitudinal magnetic field superimposed on the characteristic azimuthal magnetic field of the pinch current. The linearized solutions are developed as helical perturbations of the plasma surface. The behavior of these is given for the different cases of a uniform longitudinal

field, a longitudinal field zero inside the plasma, and for helices of the same and opposite sense to the helix which describes the total magnetic field. It is concluded that the longitudinal field has the effect of stabilizing short-wave perturbations, but that some long-wave perturbations remain unstable no matter how large the externally imposed longitudinal magnetic field. (*A/SE*, 1958)

651. THE STABILITY OF A CYLINDRICALLY SYMMETRIC PLASMA CONFIGURATION WITH VOLUME CURRENTS

Hain, K. and Lüst, R.
***Zeitschrift für Naturforschung*, v. 13a, no. 11, pp. 936–940, November 1958 (in German)**

The stability is investigated by the method of small perturbations. The problem is reduced to onlv one eigenvalue differential equation of second order. For a special current distribution with relatively strong concentration at the axis, the eigenvalues are computed numerically. For this current distribution, particularly at long wavelengths, instability shows up. The rate of growth for different kinds of perturbations are given as a function of the wavelength. (*PA*, 1959, #2445)

652. THE STABILITY OF AN INFINITELY LONG CYLINDER WITH A PREVALENT FORCE-FREE MAGNETIC FIELD

Trehan, S. K.
***The Astrophysical Journal*, p. 436, 1958**

The stability of an infinitely long cylinder of incompressible inviscid fluid of infinite electrical conductivity is investigated in case a magnetic field which is force-free and has symmetry about the axis of the cylinder prevail. It is found that the magnetic field increases the stability of the cylinder. The wavelength of the disturbance at which instability sets in for assigned strengths of the magnetic field are tabulated.

653. THE STABILITY OF A PLASMA IN CROSSED MAGNETIC FIELDS

Meyer, F.
***Zeitschrift für Naturforschung*, v. 13a, no. 12, pp. 1016–1020, December 1958 (in German)**

The stability of a plasma in crossed magnetic fields is investigated for the following equilibrium configuration. A plasma with an interior horizontal magnetic field is supported against gravity by a horizontal vacuum magnetic field which is inclined at some angle α to the interior field. This example is an extension of the case $\alpha = 0$ investigated by Kruskal and Schwarzschild. It is found that for all disturbances with small wavelengths, including those disturbances which give the Kruskal-Schwarzschild instability, stability can be restored by using a non-zero α. Perturbations of sufficiently large wavelengths are found unstable for every α and every ratio of field strength. (*AMR*, 1959, #5260)

654. THE STABILITY OF COUETTE FLOW IN AN AXIAL MAGNETIC FIELD

Niblett, E. R.
***Canadian Journal of Physics*, v. 36, no. 11, pp. 1509–1525, November 1958**

Chandrasekhar's theory of the stability of viscous flow of an electrically conducting fluid between coaxial rotating cylinders with perfectly conducting walls is extended to include the case of non-conducting walls, and it is found that their effect is to reduce the critical Taylor numbers and increase the wavelength of the instability patterns by considerable amounts. An experiment designed to measure the values of magnetic field and rotation speed at the onset of instability in mercury between perspex cylinders is described. The radioactive isotopes Hg^{197} and Hg^{203} were used to trace the flow. The results support the theoretical prediction that the boundary conditions can have a large effect on the motion. (*PA*, 1959, #1598)

655. THE STABILITY OF FORCE-FREE MAGNETIC FIELDS

Woltjer, L.
***The Astrophysical Journal*, p. 384, July–November, 1958**

The stability of force-free magnetic fields is discussed. Force-free fields are stable against a spherically symmetric expansion. The axisymmetric fields, characterized by a constant ratio of magnetic-field strength and current, are stable against all axisymmetric disturbances, the normal component of which vanishes on the surface of the field-containing region. The bearing of the results on Jean's criterion for gravitational instability is briefly discussed.

656. **THE STABILITY OF SHOCK WAVES IN MAGNETOHYDRODYNAMICS**
Akhiezer, A. I., Lyubarskii,G. I., and Polovin, R. V.
***Soviet Physics–JETP*, v. 35(8), no. 3, pp. 507–511, March 1959 (Translation)**
(*ARS Journal*, Technical Literature Digest, October 1959)

657. **THE STABILITY OF SHOCK WAVES IN MAGNETOHYDRODYNAMICS**
Syrovatskii, S. I.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, pp. 1466–1470, December 1958 (Translation in *Soviet Physics–JETP*, pp. 1024–1027, June 1959)**

Investigation of the interaction between shock waves in a magnetic field and magnetohydrodynamic waves of small amplitude. The condition for stability with respect to spontaneous emission of weak magnetohydradynamic waves by a shock wave are obtained. The conditions are found for which the linear equations for a small perturbation have no solution, this case being interpreted as the decay of the shock wave. (*A/SE*, 1959)

TURBULENCE

658. INSTABILITY, TURBULENCE, AND CONDUCTIVITY IN CURRENT-CARRYING PLASMA

Buneman, O.
Stanford University, Electronics Laboratory, Palo Alto, Calif.
AF 19(604)-1847, TR-104-1
(Also in *Physical Review Letters*, v. 1, no. 1, pp. 1–2, July 1, 1958)

659. IRREVERSIBLE STATISTICAL MECHANICS OF INCOMPRESSIBLE HYDROMAGNETIC TURBULENCE

Kraichnan, R. H.
***The Physical Review*, v. 109, no. 5, pp. 1407–1422, March 1, 1958**

The irreversible statistical mechanics of incompressible hydromagnetic turbulence driven by external forces is treated by methods which do not require that the system be close to a state of detailed balance. The equations of motion are expressed in terms of linearly independent modes formed from the wave-vector components of velocity and magnetic fields, and the nonlinear interaction is exhibited as the sum of individually conservative three-mode interactions. A fundamental statistical equation is constructed giving necessary and sufficient conditions for all members of a distribution of time-functions to satisfy the equations of motion; it involves only second-, third-, and fourth-order distribution moments. A variational criterion is proposed for specifying a distribution consistent with the fundamental equation under physically appropriate constraints. It leads to a complete formal solution of the statistical problem. This solution is not exploited. Instead, two statistical hypotheses based on the assumption of high mode density are advanced. With their aid, each three-mode interaction is treated as a small perturbation on the motion due to all the three-mode interactions and the external forces. The moments in the fundamental equation for the stationary case thereby are expressed in terms of the diagonal elements of the time-covariance matrix and distribution-averaged infinitesimal-impulse-response matrix of the system. Closed equations are obtained which fix these matrix elements in terms of the covariance matrix of the external forces. If the statistical hypotheses are sound, this provides a theory of unbounded turbulence (infinite mode density) driven by Gaussian-distributed homogeneous forces which is exact at all Reynolds numbers based on r.m.s. velocity and the macroscale determined by the driving forces. The general theory is specialized to obtain integro-differential equations determining the covariance scalars and modal impulse-response functions for stationary, isotropic hydromagnetic turbulence. In the nonmagnetic case, the asymptotic inertial-range solution yields the wave-number spectrum $E(k) = 2\pi c(\varepsilon v_0)^{\frac{1}{2}} k^{\frac{-3}{2}}$ and the modal time-autocorrelation function $J\ (2v_0 k\tau)/(v_0 k\tau)$, where v_0 is the r.m.s. velocity in any direction, ε is the mean rate of energy-cascade/unit-mass, and c is a universal number fixed by the theory. This contradicts the Kolmogorov similarity hypotheses; independent arguments are advanced against the latter. (*PA*, 1958, #2426)

660. CHANNEL TURBULENT FLOW OF AN ELECTRICALLY CONDUCTING FLUID IN THE PRESENCE OF A MAGNETIC FIELD

Lykoudis, P. S.
Purdue University, School of Aeronautical Engineering, Lafayette, Ind.
A-59-4, March 1959

Analysis considering a system of two concentric cylinders with an annulus thickness very small compared to their average radius. An electrically conducting fluid may flow in a direction parallel to the axis of the cylinders and perpendicularly to a radial magnetic field; in this case the induced current lines will be circles lying on a plane perpendicular to the stream lines. With regard to the flow, the assumption is made that the fluid is incompressible with constant scalar transport properties. Calculations of velocity profiles, skin friction, correlation coefficients, and the distortion of the magnetic field are made for different values of the Hartmann Number. (*A/SE*, June 1959)

661. TURBULENCE MEASUREMENT IN ELECTRICALLY CONDUCTING FLUIDS
Eskinazi, S.
***Physics of Fluids*, v. 1, no. 2, pp. 161–162, March–April, 1958**

Mean and turbulent velocities in a fluid were determined by measuring the resistance across a small gap (0.01 to 0.03 in.) between two point electrodes placed in the fluid. Fluid velocity distorts the electrical path and changes in velocity can therefore be detected by measuring resistance changes. It is suggested that the method could be applied to ionized gases. (*PA*, 1958, #3760)

662. SHOCK WAVES IN MAGNETOGASODYNAMIC TURBULENCE
Kaplan, S. A.
***Reviews of Modern Physics*, v. 30, p. 1089, July 1958**

The conclusion drawn is that the dissipation of shock-wave energy in interstellar turbulence is unimportant. (*NSA*, 1958, #17552)

663. RELATION BETWEEN TIME SYMMETRY AND REFLECTION SYMMETRY OF TURBULENT FLUIDS
Meecham, W. C.
***Physics of Fluids*, pp. 408–410, September–October, 1958**

Study showing that, on the basis of an assumption of statistical reflection symmetry for certain turbulent flows, some space-time velocity correlations characterizing the flow are even functions of the time delay between the correlation measurements. In particular, the second- and one of the fourth-order velocity correlations are symmetric in this relative time. (*A/SE*, December 1958)

664. THE PARTITION OF ENERGY IN HYDROMAGNETIC TURBULENCE
Chandrasekhar, S.
***Annals of Physics*, New York, v. 2, no. 6, pp. 615–626, December 1957**

The partition of energy between the velocity and the magnetic fields in hydromagnetic turbulence is discussed. It is pointed out that in the framework of a universal theory the discussion must be restricted to the inertial range of eddy sizes which does not include the largest energy containing eddies. On a particular theory of stationary, homogeneous, and isotropic turbulence it is shown that in this inertial sub-range the spectra of the magnetic and kinetic energies are both Kolmogorovian with a constant ratio of amplitudes; further, that in this range, the energy in the magnetic field is 1.6265 times the energy in the velocity field. (*PA*, 1958, #1785)

665. SHOCK WAVES IN MAGNETOGASDYNAMIC TURBULENCE
Kaplan, S. A.
***Reviews of Modern Physics*, v. 30, no. 3, p. 1089, July 1958**

Observational data on the spatial variation of velocities and magnetic fields in interstellar gas clouds are analyzed and compared with the author's spectral theory of isotropic magnetogasodynamic turbulence (*PA*, 1955, #6807). Agreement is good when the theoretical parameters refer to the case where shock-wave energy dissipation is unimportant. (*PA*, 1959, #993)

666. INSTABILITY, TURBULENCE AND CONDUCTIVITY IN CURRENT-CARRYING PLASMA
Buneman, O.
***Physical Review Letters*, v. 1, no. 1, pp. 8–9, July 1958**

Author investigates the effects of collective Coulomb interactions in fully ionized plasma. He concludes that small angle collisions cause instabilities which grow so rapidly that relative motions of ions and electrons are continually damped down by conversion of directed energy into random fluctuation energy. The implications of this effect on gas conductivity and plasma radiation are suggested. Speculations relative to explanation of Langmuir's paradox and deleterious effects in devices in which electrons are channeled through ions, or vice versa, are stated. (*AMR*, 1959, #3100)

667. HIGHER ORDER INTERACTIONS IN HOMOGENEOUS TURBULENCE THEORY
Kraichnan, R. H.
***Physics of Fluids*, v. 1, no. 4, pp. 358–359, July–August 1958**

In an earlier paper (*PA*, 1958, #2426) a theory of homogeneous turbulence was developed from the two statistical assumptions of weak-dependence and direct-interaction. Further work is now described which suggests that the second assumption is better termed the direct-interaction approximation. (*PA*, 1958, #8150)

OSCILLATIONS

668. TOROIDAL OSCILLATIONS OF A SPHERICAL MASS OF VISCOUS CONDUCTING FLUID IN A UNIFORM MAGNETIC FIELD
Stewartson, K.
***Zeitschrift für angewandte Mathematik und Physik*, v. 8, no. 4, pp. 290–297, July 1957**
(*Applied Mechanics Reviews*, 1958, #2472)

669. UNSTABLE PLASMA OSCILLATIONS IN A MAGNETIC FIELD
Harris, E. G.
***Physical Review Letters*, v. 2, no. 2, pp. 34–36, January 15, 1959**

Examines theoretically small amplitude oscillations and instabilities of a fully ionized quasi-neutral plasma in a constant uniform externally produced magnetic field set up by anisotropy of the particle velocity distributions. (*PA*, 1959, #4746)

670. A TRANSIT TIME RELATION FOR PLASMA ELECTRON OSCILLATIONS
Emeleus, K.G. and Mahaffey, D. W.
***Journal of Electronics and Control*, v. 5, no. 6, pp. 559–560, December 1958**

A relation found experimentally between tube voltage and oscillation frequency, when plasma electron oscillations are excited in a hot-cathode low-pressure discharge, is shown to be consistent with the usual assumption that modulation of the beam takes place in an oscillating sheet at a short distance from the cathode in the plasma. (*PA*, 1959, #1547)

671. THE HYDROMAGNETIC OSCILLATIONS OF AN INCOMPRESSIBLE CYLINDER
Simon, R.
***The Astrophysical Journal*, v. 128, no. 2, pp. 375–383, September 1958**

Deals with the small oscillations of an incompressible homogeneous cylinder of infinite length under its own gravity and in the presence of a uniform magnetic field parallel to its axis. Moreover, the material is supposed to be an infinitely good conductor, and the displacement currents are neglected. It is shown that the presence of the magnetic field does not alter the equations of motion but only the boundary conditions of the problem. An explicit calculation of the proper frequencies indicates a high stabilizing effect of the magnetic field. (*PA*, 1959, #7209)

672. NEW EXPERIMENTAL RESULTS FOR PLASMA ELECTRON OSCILLATIONS
Mahaffey, D. W.
***Journal of Electronics and Control*, v. 6. no. 3, pp. 193–203, March 1959**

An account of some experimental investigations of plasma electron oscillations in low-pressure mercury vapor discharges with plane oxide coated cathodes. The appearances of some of the laterally in or near the meniscus-shaped region of ionized gas brighter than the surrounding plasma, which appeared a few millimeters from the cathode. Variation of anode-cathode separation was found to have a marked effect on both the appearance of the deflected beams and the meniscus, and on the high-frequency oscillatory properties of the discharge. Measurements of plasma electron concentration and temperature were made simultaneously with measurements of oscillation intensity and frequency. A strong tendency was found for the oscillations to grow in amplitude when the beam of primary electrons moved down a concentration gradient and to die out when the beam moved up a gradient. The frequency of the oscillation was found to agree closely with that calculated from the Langmuir formula, using the plasma electron concentration at the position of appearance of the oscillation. Several checks were applied to the measurements of concentration, including measurements of the positive-ion current flowing to a probe and measurements with double probes. (*PA*, 1959, #7110)

673. AXIALLY SYMMETRIC MAGNETOHYDRODYNAMICAL MOTION. CASE OF SMALL OSCILLATIONS IN A SPHEROIDAL FLUID MASS
Agostinelli, C.
Atti dell' Accademia delle Scienze di Torino, v. 91, no. 1, pp. 263–298, 1956–1957 (in Italian)

The propagation of waves parallel to the axis is discussed in the case of a uniformly rotating liquid subject to a magnetic field applied in the direction of the axis. Small oscillations in a slowly rotating spheroid are considered in detail. The possible velocities of wave propagation for given pulsatance appear as the roots of a transcendental equation. (*PA*, 1959, #467)

674. BEAM—PLASMA INTERACTION
Mahaffey, D. W., McCullagh, G., and Emeleus, K.G.
The Physical Review, v. 112, no. 4, p. 1052, November 15, 1958

Measurements were made of plasma electron concentration and oscillation intensity through some inhomogeneous low-pressure hot-cathode discharges traversed by electron beams. A strong tendency has been found for oscillations to grow in amplitude when a beam moves down a plasma concentrating gradient and to die out when a beam moves up a gradient. (*PA*, 1959, #2434)

675. COLLECTIVE MOTION IN A SYSTEM OF QUASI-PARTICLES
Zyryanov, P. S.
Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki, v. 34, no. 2, pp. 508–509, 1958 (in Russian)
(English Summary: PB 141052T-1, obtainable from Office of Technical Services, U.S. Department of Commerce, Washington, D. C.)

In the self-consistent field approximation, the effect of strong interactions leads to a dependence of single particle (or quasi-particle) energies on the states of the other particles of the system. This gives rise to a complicated relation between the energy of the particle and its momentum. It is suggested that the momentum can be separated into two parts, one (p) being the momentum which is more properly associated with collective motion of the particles. In cases where $|p|$ is small the energy can be expanded in powers of $|p|$ and only the lowest term retained. In this way an equation for the collective motion is obtained. Application of the method to plasma oscillations is suggested. (*PA*, 1959, #9210)

676. COLLECTIVE OSCILLATIONS IN A COLD PLASMA
Auer, P. L., Hurwitz, H., Jr., and Miller, R. D.
Physics of Fluids, v. 1, no. 6, pp. 501–514, November–December, 1958

The waves considered here are linearized displacements in a plasma in which there exists a strong magnetic field, assumed as homogeneous in the special applications. Only one kind of positive ion is admitted. The temperature motions of the particles as well as any collisions are neglected, so that the medium is non-dissipative. Starting from a characteristic equation (dispersion relation) given for this case by Astrðm in 1950, authors discuss extensively the nature of the various modes that can arise. This discussion is first carried on in terms of potentials and the field quantities derived from them, and then in terms of particle orbits. It is found that when the Alfvèn dielectric constant, $4\pi n(M + m)c^2B_0^2$ becomes comparable in magnitude to the ion-to-electron mass ratio, plasma space charges may become important in the oscillations. (*AMR*, 1959, #6336)

677. CURRENT-VOLTAGE BEHAVIOUR IN A PLASMA
Gold, L.
Journal of Electronics and Control, v. 5, no. 5, pp. 432–434, November 1958

Previously an approximate solution to the current-voltage behavior in plasma oscillations had been given (*PA*, 1958, #5135). Now an exact solution is derived. It is a rather complex relation which needs numerical analysis. (*PA*, 1959, #2430)

678. FINAL REPORT ON GAS OSCILLATION PROJECT
Hudson, G. E. and Shaw, R. P.
New York University, Research Division, College of Engineering, N. Y.
DA-30-069-ORD-1090, July 1954
(ASTIA AD-40,223 A & B)

679. THE HYDROMAGNETIC OSCILLATIONS OF TWISTED MAGNETIC FIELDS I
Trehan, S. K.
***The Astrophysical Journal*, v. 127, no. 2, pp. 446–453, March 1958**

The stability of twisted magnetic fields confined to an infinitely long cylinder of incompressible inviscid fluid of infinite electrical conductivity is investigated when fluid motions are present along the lines of force and to an extent that the energies in the velocity and the magnetic fields are the same. It is found that the system is always stable. The periods of oscillation are given and discussed in the light of the corresponding stable modes of oscillation in the absence of fluid motions. (*PA*, 1958, #2428)

680. LOW-FREQUENCY PLASMA OSCILLATIONS IN A MAGNETIC FIELD
Stepanov, K. N.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, no. 5(11), pp. 1155–1160, 1958 (in Russian)**

Low-frequency electron-ion longitudinal oscillations in a plasma located in a magnetic field are considered. (*PA*, 1959, #2447)

681. THE HYDROMAGNETIC OSCILLATIONS OF AN INCOMPRESSIBLE CYLINDER
Simon, R.
***The Astrophysical Journal*, p. 375, July–November, 1958**

This paper deals with the small oscillations of an incompressible homogeneous cylinder of infinite length under its own gravity and in the presence of a uniform magnetic field parallel to its axis. Moreover, the material is supposed to be an infinitely good conductor, and the displacement currents are neglected. It is shown that the presence of the magnetic field does not alter the equations of motion but only the boundary conditions of the problem. Finally, an explicit calculation of the proper frequencies indicates a high stabilizing effect of the magnetic field.

682. MAGNETO-HYDRODYNAMIC OSCILLATIONS OF A [INFINITELY LONG CYLINDER OF] CONDUCTING LIQUID MASS ROTATING IN A UNIFORM MAGNETIC FIELD
Namikawa, T.
***Journal of Geomagnetism and Geoelectricity*, v. 7, no. 4, pp. 97–104, December 1955**

It is shown that the periods of oscillations are much different from that of non-rotating cylinder, when the Coriolis force is much larger than the electromagnetic force. Two periods T_1, T_2 for one mode of oscillation are obtained ($T_1 > T_0 > T_2$, where T_0 is the period of non-rotating cylinder). (*PA*, 1959, #470)

683. MAGNETO-HYDRODYNAMIC OSCILLATIONS OF A PERFECTLY CONDUCTING FLUID SPHERE PLACED IN A UNIFORM MAGNETIC FIELD
Rikitake, T.
***Journal of the Physical Society of Japan*, v. 13, no. 10, pp. 1224–1230, October 1958**

An attempt is made to improve theories of magneto-hydrodynamic oscillations of a conducting fluid sphere in a uniform magnetic field. Unlike the theories developed by Schwarzschild and Rikitake, analytical expressions for zonal oscillations are obtained rigorously. The eigen-periods are determined approximately. Two fundamental normal modes of oscillation are also approximately obtained and illustrated. (*PA*, 1959, #2519)

684. NOTE ON THE THEORY OF OSCILLATIONS OF AN INCOMPRESSIBLE FLUID MASS IN THE PRESENCE OF A MAGNETIC FIELD
Dricot, G. and Ledoux, P.
***Bulletin de La Société Royale des Sciénces de Liege*, v. 28, no. 5–6, pp. 115–121, May–June, 1959 (in French)**

For an incompressible mass oscillating under its own gravity and a superposed magnetic field, it is shown that the correct boundary condition (i.e., the vanishing of the Lagrangian perturbation of pressure at the surface) leads, even if the perturbation of the gravitational field has been neglected in the equation of motion, to a frequency comprising a contribution due to gravity—which is usually the dominating one. (*PA*, 1959, #7212)

685. NONLINEAR ELECTRON OSCILLATIONS IN A COLD PLASMA
Dawson, J. M.
***The Physical Review*, v. 113, no. 2, pp. 383–387, January 15, 1959**

Investigations of nonlinear electron oscillations in a cold plasma where the thermal motions may be neglected indicate that except for the simplest one-dimensional situation such oscillations will destroy themselves through the development of multistream flow. It is found possible to give an exact analysis of oscillations with plane, cylindrical, and spherical symmetry. Plane oscillations in a uniform plasma are found to be stable below a critical amplitude. For larger amplitudes it is found that multistream flow or fine-scale mixing sets in on the first oscillation. Oscillations with spherical or cylindrical symmetry develop multistream flow almost always, independent of the amplitude. The time required for mixing to start is inversely proportional to the square of the amplitude. Plane oscillations in a nonuniform plasma are also found to exhibit this type of behavior. Some considerations are also given to more general oscillations and a calculation is presented which indicates that multistream flow will usually set in. (*PA*, 1959, #4741)

686. ON ELECTRON PLASMA OSCILLATIONS IN EXTERNAL ELECTRIC AND MAGNETIC FIELDS
Stepanov, K. N. and Tkalich, V. S.
***Zhurnal Tekhnicheskoi Fiziki*, v. 28, no. 8, pp. 1789–1800, 1958 (in Russian)**

A mathematical paper. The dispersion equation is derived for oscillations within an infinite electron plasma situated in crossed electric and magnetic fields. It is supposed that the frequency of oscillation is so high that ionic motion can be neglected. Particular attention is paid to the case of a curl field. (*PA*, 1959, #362)

687. ON THE EFFECT OF COULOMB CORRELATIONS ON THE OSCILLATION SPECTRUM OF AN ELECTRON PLASMA
Zyryanov, P. S.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 34, no. 1, pp. 232–233, 1958 (in Russian)**

The effect is calculated by using the methods previously developed by the author (*PA*, 1958, #1537). (*PA*, 1959, #4750)

688. ON THE MODES OF PLASMA OSCILLATIONS IN A MAGNETIC FIELD
Braginskii, S.
***Soviet Physics–JETP*, v. 2, pp. 345–349, 1957**

689. OSCILLATIONS OF A FINITE COLD PLASMA IN A STRONG MAGNETIC FIELD
Dawson, J. and Oberman, C.
U.S. Atomic Energy Commission
NYO-8053, UF767, (40 pp.)
October 30, 1959

(Abstracted in *Battelle Technical Review*, December 1959, #14762)

690. OSCILLATIONS OF A FINITE COLD PLASMA IN A STRONG MAGNETIC FIELD
Dawson, J. and Oberman, C.
***Physics of Fluids*, v. 2, no. 2, pp. 103–111, March–April 1959**

Of prime concern in plasma investigations is the coupling of a bounded plasma with external electromagnetic fields. In the present paper the properties of the normal modes of a cold plasma slab, and cylinder, situated in a strong magnetic field are derived, and then used to discuss the transmission and reflection of radiation, the scattering by a plasma cylinder, the response to driving sources in the vicinity of the plasma, and the radiation due to plasma oscillations. (*PA*, 1959, #8252)

691. OSCILLATIONS OF ELECTRON CLOUD IN EXTERNAL FIELDS
Sumi, M.
***Journal of the Physical Society of Japan*, v. 12, no. 10, pp. 1110–1117, October 1957**

The collective behavior of density fluctuations in a purely electronic cloud which is not neutralized by positive ions is analyzed under the influence of external electromagnetic fields. In an equilibrium state the electrostatic space charge force is counterbalanced by the external fields and it gives rise to the mean drift flow of electronic cloud accompanying the oscillations similar to those in the usual plasma. The classical description leads to the dispersion relation, which involves additional terms due to the drift velocity of electron flow. The effect of this drift velocity on the frequency shift is briefly discussed. (*PA*, 1959, #8258)

692. OSCILLATIONS OF A PLASMA CYLINDER IN AN EXTERNAL MAGNETIC FIELD
Korper, K.
***Zeitschrift für Naturforschung*, v. 12a, no. 10, pp. 815–821, 1957 (in German)**

The oscillations of a plasma cylinder of infinite length are analyzed. The plasma is assumed to be homogeneous and to be exposed to a static homogeneous magnetic field in axial direction. There are two different types of oscillation. In one case the induced current is parallel to the magnetic field, and is therefore not influenced by it. In the other, where the induced current is perpendicular to the field, two resonance frequencies exist. In the limit of small density and high magnetic field these are the gyrofrequencies of the ions and the electrons. The index of refraction for both types in the limit of small frequencies is that of the hydromagnetic waves. From the basic equations the energy conservation theorem is derived. Besides the usual terms giving the electromagnetic radiation, joule's losses, and the electromagnetic energy density, it contains the kinetic energy of the ions and electrons of the plasma. (*PA*, 1959, #361)

693. OSCILLATIONS IN PLASMA. II.
Kojima, S., et al.
***Journal of the Physical Society of Japan*, pp. 821–827, June 1959**

Study of the origin of plasma-electron oscillations having slightly different frequencies, generated simultaneously in a hot cathode discharge. The oscillations are detected by means of a probe inserted into the tube or through a Yagi antenna placed on the outside. The experimental procedure is described in detail, and the results are presented for: (a) oscillations generated by the convergent beam in the central section of the tube, and (b) those generated by the divergent beam near the wall of the tube. A middle frequency oscillation observed at the periphery of the convergent beam is also mentioned. (*A/SE*, September 1959)

694. PLASMA OSCILLATIONS
Jackson, J. D.
Space Technology Laboratories, Physical Research Laboratory, Los Angeles, Calif.
AF 04(657)-165, R-GM-TR-0165-00535, December 3, 1958

An account of various aspects of plasma oscillations is given. A discussion is offered of dispersion equations, conditions necessary for the growth of decay of oscillations, the physical mechanism of growing or damping, and the possibility of arbitrary steady state solutions. The mathematical description is in terms of solutions of an initial value problem in small amplitude approximations. Some general results are derived for an arbitrary unperturbed velocity distribution of electrons and ions.

695. PLASMA OSCILLATIONS AND DISPERSION IN THE PRESENCE OF A MAGNETIC FIELD
Kantor, M.
Space Technology Laboratories, Physical Research Laboratory, Los Angeles, Calif.
AF 04(647)-165, R-GM-TR-0165-00526, November 26, 1958

A study was made of harmonic oscillations which may exist in a fully ionized, collision-free, homogeneous plasma subjected to a steady magnetic field. The plasma consists of a binary mixture of electrons and ions for which electrical neutrality is preserved. The system is described by writing the Maxwell second-order electrodynamic wave equation and the linearized equations of macroscopic motion of the particles. It is shown that the various kinds of hydromagnetic waves all belong to the fundamental or lowest of the four modes of propagation in the quartic in the square of the propagation vector.

696. PLASMA OSCILLATIONS IN AN EXTERNAL STATIC MAGNETIC FIELD
Chulli, S. and Miku, M.
***Revue de Physique*, Bucharest, v. 3, no. 3–4, pp. 211–218, 1958 (in Russian)**

Reports studies of the steady-state distribution and small departures from it (oscillations) of a discharge in a gas under the action of an external axial constant magnetic field. (*PA*, 1959, #8252)

697. PLASMA OSCILLATION IN DEGENERATE ELECTRON GAS
Horie, C.
***Science Reports of the Tôhoku University*, Sendai, First Series, v. 41, no. 4, pp. 188–194, January 1958**

An approach to the treatment of the collective behavior of a dense system is developed, and the conditions which the collective variables representing collective motion must satisfy are given. These variables are introduced similarly to Tomonaga's treatment, but are different from it in that they contain an unknown factor which is deter-

mined so as to satisfy the conditions mentioned above. These conditions ensure that the separation of the part representing the collective motion from the original Hamiltonian is almost complete. Application to the system of a degenerate electron gas yields a dispersion relation for the plasma frequency which is the same as that derived by Bohm and Pines. (*PA*, 1959, #5834)

698. PLASMA OSCILLATIONS WITH DIFFUSION IN VELOCITY SPACE

Lenard, A. and Bernstein, I. B.
***The Physical Review*, v. 112, no. 5, pp. 1456–1459, December 1, 1958**

A model of plasma oscillations in the presence of small-angle collisions is presented which admits of exact analytic solution. Certain features of the true collision terms are preserved. Namely, the effect of collisions is represented by a diffusion in velocity space, which makes the distribution function tend to the Maxwell distribution, and which conserves the number of particles. In the limit of infrequent collisions the results of Landau are recovered. (*PA*, 1959, #2436)

699. STUDY OF MILLIMETER WAVE PLASMA OSCILLATION

(Period covered: December 1956–February 1957)
Bloom, S., et al.
Radio Corporation of America, RCA Laboratories
QR-3, DA-36-039-SC-72793
February 28, 1957
(ASTIA AD-132,929)

An experiment for measurement of the plasma density of the hollow cathode glow discharge is described; good agreement with theory is shown. The problem of plasma oscillation excitation is discussed. Studies of electron extraction from an arc discharge plasma are described.

700. SMALL PERTURBATIONS IN HYDROMAGNETICS, FREE OSCILLATIONS IN A RECTANGULAR BOX, AND THE PERFECTLY CONDUCTING GAS

Ludford, G. S. S.
Maryland, University of, Institute of Fluid Dynamics and Applied Mathematics, College Park
TR BN-143, AFOSR TN 58-700, July 1958
(ASTIA AD-162,234)

Analysis of the small perturbations of an electrically conducting inviscid gas in the presence of a uniform undisturbed magnetic field. The free oscillations in a rectangular box are determined and used to examine the limit of infinite conductivity. Plane waves are discussed. The system of first-order linear differential equations governing the motion is considered. It is shown that by suitable transformation the general perturbation equations can be split into sets of four and five, each set leading to a partial differential equation of the same order. The standing waves in the fluid confined in a rectangular perfectly conducting box, into which a uniform magnetic field perpendicular to two of the faces has been frozen, is examined; these waves are of three types. The limiting forms of the waves for two extreme cases are discussed. The general initial-value problem and the determination of Fourier coefficients appropriate to the orthogonal system defined by the standing waves are also discussed. (*A/SE*, December 1958)

701. STUDY OF PLASMA OSCILLATIONS IN A MAGNETIC FIELD

Bandel, H. W., Drummond, J. E., and Hill, R. M.
Sylvania Electric Products, Inc., Microwave Physics Laboratory, Mountain View, Calif.
MPL-6, TR, July 17, 1957
(Work Initiated at Electronic Defense Laboratory Under Contract DA-36-039-sc-71053 and Continued at Microwave Physics Laboratory Under Contract DA-36-039-sc-73188)

A study has been made of oscillations which occur within a gas-filled smooth anode magnetron. Nelson's experimental observations have been generally verified. The main purpose of this work was to determine the configuration and mechanism of the oscillations; this work has met with partial success. Simultaneous relative phase and amplitude measurements of signals from probes inside the anode as a function of azimuthal angle have shown that there is no azimuthal variation. This rules out Nelson's theory and, along with other experimental observations, has made possible the development of a new theory of the oscillations. The theory of oscillation has been developed which begins by postulating the symmetry and other conditions found by experiment.

702. THE HYDROMAGNETIC OSCILLATIONS OF TWISTED MAGNETIC FIELDS. II
Trehan, S. K. and Reid, W. H.
***The Astrophysical Journal*, v. 127, no. 2, pp. 454–458, March 1958**

The stability of twisted magnetic fields imbedded in a conducting fluid which extends to infinity is investigated when fluid motions are present along the lines of force. It is found that this configuration is always stable for cylindrically symmetric disturbances. The periods of oscillation are obtained by a variational method and are found not to differ greatly from the corresponding results for twisted magnetic fields confined to a cylinder of finite radius. (*PA*, 1958, #2429)

703. THE OSCILLATIONS OF AN INFINITE CYLINDER OF GAS WITH INTRINSIC GRAVITATION IN A MAGNETIC FIELD
Yavorskaya, I. M.
***Akademii Nauk SSSR, Doklady*, v. 114, no. 5, pp. 988–990, 1957 (in Russian)**

Theoretical paper. The problem of the irregular motion of a gas is considered with a basic assumption that the electrical conductivity is high enough for the lines of magnetic force to be "frozen" in the medium. Also discussed are the radial motions of a gas with cylindrical symmetry under the action of Newtonian tension forces and internal magnetic field. The motion of a gas is also considered when velocity varies linearly with distance from the axis of symmetry. (*PA*, 1958, #63)

704. THE STABILITY OF A PLANE PLASMA SHEET OSCILLATING BETWEEN CONDUCTING WALLS
Tayler, R. J.
Atomic Energy Research Establishment, Harwell, England
AERE-T/R-2786, September 30, 1959

A stable plasma can execute regular oscillations in a conducting tube. If its surface is perturbed at the moment it is reflected by the wall, the perturbation will either be smoothed out by the reflection or will become more important on successive reflections. It is shown, for a very simplified problem, that such perturbations can grow at a rate which is comparable with the period of the main oscillation. If this result is true it is an example of a non-linear instability. It is not clear, at the moment, whether the non-linear terms do lead to a true instability or whether they transfer energy from one stable oscillation to another.

FLUID MECHANICS

705. THERMODYNAMICS OF ELECTRICALLY CONDUCTING FLUIDS AND ITS APPLICATION TO MAGNETO-HYDROMECHANICS

Chu, B. T.
Brown University, Division of Engineering, Providence, R. I.
WADC TN 57-350, December 1957 (31 pp.)
(ASTIA AD-142,039)

Professor Chu has studied the thermodynamics of electrically conducting fluids from a consideration of the Helmholtz free energy per unit mass. The principal assumptions are that the fluid is isotropic and hence the free energy is independent of the orientation of the coordinate system, and that the dielectric constant and magnetic permeability are known functions of density and temperature. A consequence of these assumptions is that the free energy, and hence thermodynamic properties, all consist of the standard mechanical and thermal terms plus an electromagnetic term. The electromagnetic contribution to the entropy depends only on the derivative of the dielectric constant and the magnetic permeability with respect to the temperature. Hence if these properties are either independent of temperature (i.e., a Lorentz polarization and a perfect diamagnetic substance) or follow Langevin's assumption (a perfect dielectric and a paramagnetic substance), the familiar formula for isentropic changes holds, but the ratio of specific heat may include electromagnetic contributions.

The conservation equations are derived on the basis of the thermodynamics. Finally, Professor Chu critically discusses the energy equation of magneto-fluid-dynamics in terms of his development of the thermodynamics and the general assumptions about the dielectric constant and the magnetic permeability. This discussion should be recommended reading for all students of magneto-fluid-dynamics.

In the application of the results presented in this report to a situation in which the external electric and magnetic fields are strong, it should be remembered that the fields might not be isotropic since the effect of these fields is to introduce anisotropic effects. The Hall current and the propagation of acoustic waves are two well-known examples of the anisotropic processes. The effects of these anisotropic occur, for the most part, in the material properties, i.e., the viscosity electrical and thermal conductivity, etc. Consequently, if these effects are allowed for, it is expected that Chu's conservation equations are still valid. (*AMR*, 1959, #1559)

706. APPLICATIONS OF MAGNETOFLUIDMECHANICS

***Space/Aeronautics*, p. 30, October 1959**

707. MAGNETO-FLUID-MECHANICS OF A VISCOUS ELECTRICALLY CONDUCTING FLUID CONTAINED WITHIN TWO FINITE, CONCENTRIC, ROTATING CYLINDERS IN THE PRESENCE OF A MAGNETIC FIELD

Pneuman, G. W. and Lykoudis, P. S.
Purdue University, School of Aeronautical Engineering, Lafayette, Ind.
Research Project 1717, Project Ae-33, A-59-13
August 1959

708. ON SOME FUNDAMENTALS IN MAGNETO-FLUID-MECHANICS

(Thesis)
Covert, E. E.
Massachusetts Institute of Technology, Naval Supersonic Laboratory, Cambridge
TR 247, NP-6969, March 1958

The basic equations of magneto-fluid-mechanics are derived from classical kinetic theory for a gas consisting of neutral particles, positive particles (ions), and electrons. Included are the equations of conservation of mass and momentum for each type of particle, an energy equation, the Maxwell equations of electrodynamics, and suitable state equations. The basic equations are normalized and the resulting dimensionless parameters are discussed. Formulas for the fluid properties are presented, and a

summary of the values of these properties is given. Some elementary solutions are given to illustrate the nature of magneto-fluid interactions. The problem of adding energy to a gas by magneto-fluid mechanical means is discussed and it is concluded that these means are practical only at high power densities (i.e., 700 kw/ft^2 $\sim 5 \times 10^6$ Btu/sec/ft^2). A device which absorbs such power densities and generates a plasma is discussed theoretically and some preliminary experimental results from the device are given. (*NSA*, 1959, #7854)

HEAT TRANSFER

709. ON SOME PROBLEMS IN RADIATIVE HEAT TRANSFER

Arbanel, S. S.
Massachusetts Institute of Technology, Fluid Dynamics Research Group, Cambridge
HF 49(638)-207, Group Report 59-1

The time-dependent and steady temperature distributions in radiating homogeneous solid conductors are considered.

710. HEAT TRANSFER FROM DISSOCIATED GASES IN A SHOCK TUBE

Hartunian, R. A. and Marrone, P. V.
Cornell Aeronautical Laboratory, Inc., Ithaca, N. Y.
AF 18(603)-141, R-AD-1118-A-7, November 1959

Measurements have been made over a wide range of operating conditions using the methods of thin-film thermometry. Comparison of the experimental results with the correlated theoretical solution has led to an evaluation of the viscosity coefficient of dissociated oxygen. Techniques for use of thin-film thermometers to measure heat transfer from ionized gases and to study effects of surface catalytic efficiency on the heat transfer from dissociated gases are described and experimental results using latter technique are discussed.

711. AN EXPERIMENTAL STUDY OF THE OPERATING CHARACTERISTICS AND ELECTRODE HEAT TRANSFER OF A DIRECT CURRENT ELECTRIC ARC IN A PRESSURIZED ARGON ENVIRONMENT

Palmer, G. M., Paris, F. L., Jr., et al.
Purdue University, School of Aeronautical Engineering, Purdue Research Foundation, Lafayette, Ind.
R-A-59-10, Research Project 1717, Project AE-33, August 1959

The effect of pressure on the operating characteristics and energy distribution of the electric arc between metallic electrodes in argon is studied. A necessary prerequisite of this study is an investigation of the arc path with different anode and cathode geometries to determine a system for which the arc will follow the shortest geometric path.

712. EFFECT OF A MAGNETIC FIELD ON FORCED CONVECTION HEAT TRANSFER IN A PARALLEL PLATE CHANNEL

Siegel, R.
***Journal of Applied Mechanics*, v. 25, no. 3, pp. 415-416 (Notes), September 1958**

The steady flow of a conducting liquid, between two parallel plates, under the influence of a transverse magnetic field has been studied by Hartmann and Lazarus (see T. G. Cowling, "Magneto-fluid-dynamics," Interscience, 1957). Their solution is used in the present paper to determine the temperature distribution in the liquid, which depends partly on the heat transfer across the plates and partly on joule heating. Relatively simple expressions are found for the constant temperature gradient along the direction of flow and for the wall temperature in terms of the mean temperature of the fluids. (*AMR*, 1959, #1558)

713. ON SOME PROBLEMS OF HEAT TRANSFER IN FREE MOLECULE FLOW

Krzywoblocki, M. Z. V. and Bergonz, F. H.
***Acta Physica Austriaca*, v. 12, pp. 400–411, 1959**

The general theory for aerodynamic heating in free molecule flow is briefly presented. This is then applied to a cone and a paraboloid of revolution in an attempt to predict surface temperatures. Only the aerodynamic effects are considered, i.e., the entire heat transfer to the body is made by the energy exchange of the gas molecules only. No effect of radiation to or from the body is considered. (*NSA*, 1959, #286)

714. HEAT TRANSFER IN A DISSOCIATED GAS

Greifinger, P.
RAND Corporation, Santa Monica, Calif.
RM-2244, August 28, 1958
Projects: RAND

An evaluation of the effects of finite reaction kinetics on heat transfer. The model considered is a chemically reacting gas confined between two plates maintained at different temperatures. The specific type of chemical reaction investigated is the dissociation-recombination $X2 \leftrightharpoons 2X$.

715. MAGNETO-FLUID-DYNAMICS ANALYSIS OF HEAT TRANSFER NEAR A STAGNATION POINT

Rossow, V. J.
***Journal of the Aeronautical Sciences*, v. 25, no. 5, pp. 334–335 (Readers' Forum), May 1958**

Author calculates the reduction in heat transfer at a two-dimensional stagnation point in an incompressible, constant property fluid due to a magnetic field alined with the free-stream direction. The work is an extension of the analysis reported in NACA TN 3971, 1957, wherein the effect of a magnetic field on the skin friction was studied. The secondary magnetic field induced by the motion of the fluid through the primary field is neglected throughout. Joule heating and viscous dissipation terms are carried in the energy equation. Computing machine solutions show that 16 percent reductions in heat transfer at the stagnation point and in its vicinity accrue with moderate field strength and conductivities. (*AMR*, 1959, #1033)

716. THE INFLUENCE OF GAS DISSOCIATION ON HEAT TRANSFER

Thievon, W. J., Sterbutzel, G. A., et al.
Cornell Aeronautical Laboratory, Inc., Ithaca, N. Y.
AF 33(616)-5143, WADC-TR-59-450, June 1959

Recovery factor and heat-transfer rates for dissociating N_2O_4 gas were determined experimentally under turbulent flow in a tube. The range of flow rates for the recovery factor tests was from 208,580, to 722,480 lb/hr-ft^2 with a diameter Reynolds number of 89,420 to 541,100. The range for the heat transfer measurements was from 21,000 to 90,000 lb/hr-ft^2 at a length Reynolds number of 65,000 to 2,000,000.

717. HYDROMAGNETIC EFFECTS ON STAGNATION-POINT HEAT TRANSFER

Neuringer, J. L. and McIlroy, W.
***Journal of the Aeronautical Sciences*, v. 25, no. 5, pp. 332–334, (Readers' Forum), May 1958**

Authors calculate the reduction in heat transfer at a two-dimensional stagnation point in an incompressible, constant property fluid due to a magnetic field aligned with the free-stream direction. The work is an extension of the analysis reported in *Journal of the Aeronautical Sciences*, v. 25, no. 3, pp. 194–198, March 1958, wherein the reduction of the skin friction due to the magnetic field was evaluated. In the latter analysis the change in the imposed magnetic field induced by the electric currents in the fluid is fully taken into account. However, in the heat-transfer solution, the effect of the magnetic field is introduced only insofar as it influences the flow-velocity components, the effects of Joule heating and viscous dissipation being neglected as small. Results of machine computations show that the stagnation point heat transfer can be reduced by as much as 28 percent by a magnetic field of reasonable strength in a fluid of relatively small electric conductivity.

The same problem has been solved by Rossow in a slightly different way. In Rossow's solution the change in the imposed magnetic field induced by the electric current is neglected in the momentum equations, but the joule heating and viscous dissipation terms are retained in the energy equation. The numerical results of the two analyses are the same for practical purposes. (*AMR*, 1959, #1034)

718. MAGNETOHYDRODYNAMIC EFFECTS UPON HEAT TRANSFER FOR LAMINAR FLOW ACROSS A FLAT PLATE

Cess, R. D.
American Society of Mechanical Engineers, New York, N. Y.
Pa 59-HT-14, May 4, 1959

Forced-convection heat transfer for laminar flow of electrically conducting fluids across a flat plate is considered for a magnetic field of constant inductance acting normal to the free-stream velocity and fixed relative to the plate. The boundary condition on the surface of the plate is taken to be either a constant temperature or constant heat flux. Solutions are presented for fluids having a Prandtl number of unity, greater than unity, and less than one.

719. ON REDUCING AERODYNAMIC HEAT TRANSFER RATES BY MAGNETOHYDRODYNAMIC TECHNIQUES

Meyer, R. C.
Institute of the Aeronautical Sciences, Inc., New York, N. Y.
Preprint 816, January 1958 (25 pp., 7 fig., 8 ref.)

The possibility of reducing stagnation point heat-transfer rates on blunt bodies at hypersonic speeds by means of a magnetic field is considered. The modification of the flow within and external to the viscous boundary layer is analyzed. It is concluded that the primary mechanism which serves to reduce the heat transfer is an alteration of the inviscid flow external to the boundary layer. A preliminary analysis shows that at Mach 25 and 100,000 ft altitude the heat transfer may be decreased approximately 20 percent for an applied field strength of 8 kilogauss. (*Index Aeronauticus*, June 1958)

RADIATION

720. SURFACE VIBRATIONS OF A [HYDRODYNAMIC] CHARGED COLUMN IN A LONGITUDINAL [EXTERNAL] MAGNETIC FIELD
Kéi-Khua, C.
***Zhurnal Eksperimentalnoi i Fiziki*, v. 35, no. 6 (12), pp. 1475–1480, 1958 (in Russian)**

The investigation is an extension of the work of Kruskal and Schwarzschild (*PA*, 1954, #6324) and Tayler (*PA*, 1957, #4411; *PA*, 1958, #631) on the stability of an uncharge hydrodynamic column. A dispersion equation for surface waves is found and various consequences relating to the vibration spectrum are analyzed. From the experimental standpoint, these results may be useful for elucidation of the nature of radiation from a plasma in a magnetic field. (*PA*, 1959, #12509)

721. SPECTRAL DISTRIBUTION OF BREMSSTRAHLUNG FROM AN IONIZED GAS
Mahendra, S. S.
***Canadian Journal of Physics*, v. 37, no. 12, p. 1380, December 1959**

Using Heitler's and Sommerfeld's cross-section the spectral distribution of bremsstrahlung from an ionized gas has been calculated, neglecting self-absorption and stimulated emission. These results can be used to calculate the spectral distribution of bremsstrahlung from a mass of ionized gas, considering self-absorption and stimulated emission if one utilizes the expression obtained by Allen and Hindmarsh.

722. BREMSSTRAHLUNG FROM A MAXWELLIAN GAS
Greene, J.
***The Astrophysical Journal*, p. 693, September 1959**

723. BREMSSTRAHLUNG FROM DENSE PLASMAS
Griem, H. R., Kolb, A. C., and Faust, W. R.
***Physical Review Letters*, v. 2, no. 7, pp. 281–282, April 1, 1959**

Shock preheated deuterium was compressed in a magnetic mirror with fields rising to 1.25 and 2×10^5 gauss in ~ 5 μsec. A central region of the plasma about 2–3 mm diameter at maximum compression, emits continuous radiation observed in the visible on a streak spectrograph and in the X-ray region between 1.6 and 8 kev photographically through a Be window. From measured absolute intensities, electron temperatures of 5.5 and 8×10^6 °K and electron densities of 4 and 7×10^{16} cm $^{-3}$ are inferred for the above peak fields, respectively. (*PA*, 1959, #12410)

724. COMPARISON OF LOW GAS DENSITY FLOW VISUALIZATION TECHNIQUES
Kunkel, W. B.
Max Planck Institute, Germany
Special Report, March 7, 1956, AF 61(514)-911 (ASTIA AD-96,508)

The density-dependent phenomena investigated as a tool for low-density flow visualization are: (1) true absorption of suitable electromagnetic radiation; (2) scattering and apparent absorption of electrons; and (3) the emission of electromagnetic radiation.

725. EFFECT OF ADSORBED NITROGEN ON THE THERMIONIC EMISSION FROM LANTHANUM HEXABORIDE
Carter, A. F. and Wood, G. P.
National Aeronautics and Space Administration, Washington, D.C.
Memo 2-16-59L, March 1959 (12 pp.)

The emission properties of lanthanum hexaboride in an atmosphere of nitrogen were investigated. The emitter was not poisoned by adsorbed nitrogen. This result should have application to magnetohydrodynamic devices. (*AMR*, 1959, #4730)

726. ELECTROMAGNETIC RADIATION FROM SOURCES ON AND NEAR CYLINDRICAL SURFACES
Wait, J. R.
Commerce Department, National Bureau of Standards, Boulder Laboratories, Colo.
R-5553, January 15, 1958

727. ELECTROMAGNETIC RADIATION FROM AN IONIZED HYDROGEN PLASMA
Berman, S. M.
Space Technology Laboratories, Inc., Physical Research Lab., Los Angeles, Calif.
R-PRL 9-27, September 24, 1959

This report gives an account of the radiant energy emitted by a hydrogen plasma in the temperature range from 0.7 to 9.0 ev due to the processes of recombination of electrons and protons to form hydrogen atoms, bound–bound transitions of excited hydrogen atoms, and bremsstrahlung of free electrons.

728. ELECTROMAGNETIC RADIATION THROUGH THE ATMOSPHERE
Beyers, N. J.
Army Dept. Ordnance, White Sands Proving Ground, N. M.
Signal Corps Agency, Missile Geophysics Program, Airborne Refractometer Installation
PR-2, January 11, 1957

The type VI microwave refractometer, designed to measure large-scale refractive index charges, is described. The measurements of index of refraction are made at a frequency of approximately 9400 Mc.

729. FLUXES AND NONDIMENSIONAL PARAMETERS IN RADIANT GASES
Goulard, G.
Purdue University, School of Aeronautical Engineering, Lafayette, Ind.
Research Project Number 1717, Project Ae-33, Report A-59-8, October 1959

730. HYDRODYNAMICS IN A RADIATION FIELD—A COVARIANT TREATMENT
Hazlehurst, J. and Sargent, W. L. W.
***Ths Astrophysical Journal*, p. 276, July 1959**

731. INTERACTION BETWEEN A CHARGED CURRENT-CARRYING JET MOVING IN A CIRCLE AND A MAGNETO-DIELECTRIC
Didenko, A. N.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 35, no. 3(9), pp. 655–661, 1958 (in Russian)**

The radiation spectrum of a current-carrying charged jet moving in a circle in homogeneous space is studied. The radiation spectra and lateral forces exerted by the magnetodielectric are investigated for some particular cases of inhomogeneous spaces using Bessel functions and Neuman functions which yield a good approximation even at comparatively small values of the indices and arguments. (*PA*, 1959, #2523)

732. INVESTIGATION OF A CURRENT-CARRYING RING UNIFORMLY MOVING IN A PLASMA LOCATED IN A MAGNETIC FIELD
Bogdankevich, L. S.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 36, no. 3, pp. 835–838, 1959 (in Russian)**

Energy losses due to Vavilov-Čerenkov radiation are computed for a current-carrying ring uniformly moving in a plasma perpendicular to its plane and parallel to the external magnetic field. (*PA*, 1959, #12414)

733. MICROWAVE EMISSION FROM HIGH TEMPERATURE PLASMAS
Beard, D. B.
***Physical Review Letters*, v. 2, pp. 81–82, February 1, 1959**
(*ARS Journal*, Technical Literature Digest, November 1959)

734. NUMERICAL CALCULATION OF ABSOLUTE BREMSSTRAHLUNG INTENSITY FOR A FULLY DISSOCIATED HYDROGENIC GAS
Janes, G. S. and Koritz, H. E.
AVCO Corp., AVCO-Everett Research Lab., Everett, Mass.
R-70, September 1959
AF 49(638)-61, AFOSR TN 59-1076

Using the approximate relationships of Kirkpatrick and Weidmann for bremsstrahlung intensities, numerical calculations have been made for a fully ionized, fully dissociated hydrogenic gas. A calibration method has been

devised for measurement of absolute bremsstrahlung intensities, which continually compensates for the errors present in most calibration procedures.

735. OBSERVATIONS ON GAS IONIZING RADIATIONS

Przybylski, A. and Raether, H.
***Zeitschrift für Naturforschung*, v. 13 a, no. 3, p. 234, March 1958 (in German)**

Briefly describes measurements of the absorption coefficients for photoionizing radiations in gases using an ionization chamber absorber region. Data for oxygen are given. A value of absorption coefficient $\mu = 38$ cm^{-1} at 760 mm Hg was obtained. (*PA*, 1959, #2454)

736. OCCURRENCE OF VAVILOV–CERENKOV RADIATION IN A HIGH-TEMPERATURE PLASMA

Newfeld, J.
***The Physical Review*, 2nd Series, v. 116, no. 1, October 1, 1959**

737. ON THE IONIZATION STATE AND THE RADIATION FROM IMPURITY GASES IN A HYDROGEN PLASMA

Knorr, G.
***Zeitschrift für Naturforschung*, v. 13a, no. 11, pp. 941–950, 1958 (in German)**

An interpretation formula is derived for excitation and ionization of ions which is claimed to be valid over the whole energy range of colliding electrons. This formula is used to compute a time constant which characterizes the time scale on which the ionization equilibrium of heavier ions becomes established. Elwert's ionization formula is generalized for small values of the ratio ionization-energy/KT. Neglecting interaction between radiation and plasma, the radiation of impurities, i.e., free-free, free-bound, and excitation radiation are computed. (20 ref.) (*PA*, 1959, #5837)

738. PHOTODETACHMENT CROSS-SECTION AND THE ELECTRON AFFINITY OF ATOMIC OXYGEN

Branscomb, L. M., et al.
***The Physical Review*, v. 111, no. 2, pp. 504–513, July 15, 1958**

Experiments and theory on the continuous absorption of radiation by atomic-oxygen negative ions are described and discussed. The absorption cross section for photon energies not too near threshold is obtained directly from one of the experiments. Theory and experiment are combined to give the cross section in the vicinity of threshold and a precise value of the electron affinity of atomic oxygen. The latter result is $EA(O) = 1.465 \pm 0.005$ ev. The data are used for computation of the radiative attachment coefficient, and other applications of the experimental results are discussed. The potential astrophysical importance of O^- absorption is suggested by the influence of H^- photodetachment on the solar continuous spectrum. (*PA*, 1959, #2432)

739. PLASMA RADIATION IN A MAGNETIC FIELD

Trubnikov, B. A.
***Soviet Physics–JETP*, USSR, pp. 136–140, January–February 1958 (Translation)**

Theoretical analysis of plasma radiation due to the revolutionary motion of electrons in a uniform magnetic field; only the high harmonics are considered. (*A/SE*, November 1959)

740. RADIATION BY PLASMA OSCILLATIONS IN A BOUNDED PLASMA IN A MAGNETIC FIELD

Wyld, H. W., Jr.
Space Technology Laboratories, Inc., Physical Research Laboratory, Los Angeles, Calif.
R-PRL-9-23, October 23, 1959

The radiation by a thermal distribution of plasma oscillations in a bounded plasma in a magnetic field is calculated in the limit $(\omega_c/\omega_p)^{1/2} << 1$, where ω_c and ω_p are the cyclotron and plasma frequencies. The calculation is performed in two ways leading to the same result. The results are compared with the synchrotron radiation by a plasma in a magnetic field.

741. RADIATION OF PLASMA IN A MAGNETIC FIELD

Trubnikov, B. A.
***Reports of the Academy of Sciences*, USSR, v. 118, no. 5, 1958 (Presented by Academician Leontovich, M. A.,on September 10, 1957. Translated from the**

Russian by Burke, R. D.)
RAND Corp., Santa Monica, Calif.
T-101, October 8, 1958

742. SOME OBSERVATIONS ON THE EFFECT OF RADIATION ON THE REFRACTIVE INDICES OF CERTAIN GASES

Crain, C. M.
Journal of Applied Physics, v. 29, no. 11, pp. 1605–1606, November 1958

Radiation from a nuclear reactor and from a Co^{60} source was passed into a cavity resonator containing, in turn, air, argon, and nitrogen at various pressures, and the free-electron density was deduced from the change in refractive index. In the case of air, the refractive index remained constant within 1 in 10^8 for pressures from 100 μ to 1 atmosphere. This indicates a free electron density less than 10^4 electrons per cm^3 for air; assuming that electron loss is due to attachment to the oxygen nucleus, this gives a value of 10^{-19} cm^2 for the attachment cross section, which does not agree with Biondi (*The Physical Review*, v. 84, no. 5, p. 1072, December 1, 1951). In the cases of argon and nitrogen the variation was a few parts in 10^6 as the pressure varied from 2 to 76 cm Hg; this variation was a few parts in 10^6 as the pressure varied from 2 to 76 cm Hg; this variation was greatly reduced by introduction of atmospheric air, and there is a possibility that use of high purity argon or nitrogen would have led to a greater change in refractive index. (*PA*, 1959, #9389)

PROPULSION

743. THRUST ORIENTATION PATTERNS FOR ORBITAL ADJUSTMENT OF LOW THRUST VEHICLES

Brown, H. and Nelson, J.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.

Low-thrust propulsion systems can be used for the precision adjustment of space vehicle orbit characteristics. The most effective application of these low levels of thrust requires the use of thrust orientation patterns peculiar to each type of mission. The thrust patterns most suitable for altitude correction, eccentricity reduction, and Earth-escape missions are identified and typical propulsion times indicated.

744. ETUDES PRELIMINARIES SUR LES SYSTEMS DE PROPULSION ELECTRIQUE POUR LES VOYAGES DANS L'ESPACE

Fox, R.
***I.P.A. Bulletin*, no. 32, pp. 3–9, March 28, 1959**
(*Bulletin mensuel signalétique*, June 1959)

745. COMPARISON OF ADVANCED PROPULSION SYSTEMS: SOLAR-HEATING, ARC THERMODYNAMICS AND ARC MAGNETO-HYDRODYNAMICS

Ehricke, K. A.
CONVAIR/Astronautics Division, San Diego, Calif.
AZK-002, December 1, 1957

A very thorough comparison of these three types of propulsion systems is given.

746. PULSED PLASMA ACCELERATOR

Thourson, T. L.
AVCO Manufacturing Corp., Everett, Mass.
October 7–8, 1959 (Meeting)

Various types of plasma accelerators utilizing a Lorentz force for acceleration of plasma are described. These include the Bostick source, the rail type gun, the AVCO coaxial shock tube and the Kolb shock tube. An analysis of operation of plasma accelerators is given.

747. MAGNETOHYDRODYNAMIC ACCELERATION OF SLIGHTLY IONIZED VISCOUSLY CONTAINED GASES

Janes, G. S. and Fay, J. A.
AVCO Manufacturing Corp., Everett, Mass.
October 7–8, 1959 (Meeting)

The various physical aerodynamic factors affecting the design of a steady flow MHD accelerator having viscous containment and crossed electric and magnetic fields are considered for the case of a slightly ionized gas. These include the effects of tensor electrical conductivity, ion slip, current diffusion, frozen flow and leaving losses, magnetic field and electrode losses, and viscous boundary layer losses. Some of these effects are also applicable to the case of a completely ionized gas.

748. A COMPARISON OF THE SPECIFIC THRUST OF ION AND PLASMA DRIVE ACCELERATORS

Kash, S. W.
AVCO Manufacturing Corp., Everett, Mass.
October 7–8, 1959 (Meeting)

The parameter specific thrust T_{sp} is introduced and estimates are given for the maximum T_{sp} for ion drive and plasma drive accelerators. The maximum T_{sp} for plasma drive is at least one hundred times as great as that for ion drive. The limitation on ion drive T_{sp} cannot be overcome with a double-grid accelerate-decelerate system. Charged colloidal particle accelerators will provide a T_{sp} even lower than that of the heavy ion accelerator. The relationships between T_{sp} and the efficiency and mass flow rate are shown.

749. PLASMA ACCELERATOR FOR SPACECRAFT CONTROL (Design Progress)
Kovit, B.
Space/Aeronautics, p. 57, March 1959

750. STATE OF THE ART: PROPULSION
Space/Aeronautics, p. 52, March 1959

751. ADVANCED PROPULSION SYSTEMS; A PRELIMINARY STUDY
Calcote, H. F.
AeroChem Research Laboratories, Inc., Princeton, N.J.
TP-6, July 1958
Nonr-2336(00), PB-151,796

A critical study was made of some advanced propulsion systems with particular attention to the propulsion motor and the power source as separate units. The primary objectives were to evaluate the state of the art and estimate fruitful lines for future research. The general principles of propulsion as they pertain to non-conventional systems were reviewed.

752. A PRELIMINARY ENGINEERING EVALUATION OF ADVANCED SPACE PROPULSION SYSTEMS. VOLUME I.—GENERALIZED PROPULSION SYSTEM ANALYSIS AND MISSION REQUIREMENTS
Masser, P. S., Page, R. J., and Stoner, W.
Plasmadyne Corp., Santa Ana, Calif.
AFWADC-TR-59-189(I) March 25, 1959

753. FACTORS INFLUENCING THE APPLICATION OF UNCONVENTIONAL ENGINE SYSTEMS
Gill, G. S. and Kusak, L.
Society of Automotive Engineers Preprint 54S
March 31–April 3, 1959 (15 pp.)
(*ARS Journal*, November 1959)

754. PLASMA ACCELERATION BY MEANS OF A ROTATING MAGNETIC FIELD
Vali, V. and Gauger, J.
Lockheed Aircraft Corp., Missiles and Space Division, Sunnyvale, Calif.
TR LMSD-48381, v. III, pp. 35–41, January 1959

Development of a technique for accelerating hydrogen plasmas to velocities of the order of 1% of the velocity of light. At this velocity, the kinetic energy per particle of a deuterium plasma is approximately 10^5 ev. The system would utilize an electrodeless discharge so that no high atomic number contaminants are introduced, other than those boiled off the gas container walls. The apparatus would consist of a cylindrical glass tube with four radio-frequency oscillator coils placed around it to produce a rotating magnetic field. (*A/SE*, April 1959)

755. A MAGNETOHYDRODYNAMIC MODEL FOR A TWO-DIMENSIONAL MAGNETIC PISTON
Meyer, R. X.
Space Technology Labs., Inc., Los Angeles, Calif.
PRL TR 59-0000-00617, March 4, 1959 (12 pp.)

USAF-supported calculation of the mass flow rate of gas leaking through the magnetic piston in the regime of continuum flow. The analysis is confined to a plane geometry rather than to a rotationally symmetric one. The principal assumption throughout the analysis consists in neglecting the kinetic energy of the gas (in a coordinate frame attached to the piston) compared with its internal energy and compared with the energy of the magnetic field. The gas therefore "percolates" through the field somewhat analogously to a liquid percolating through a porous medium. This assumption is verified numerically and a typical example is considered.

756. A PROPULSION DEVICE USING AN EXPLODING-WIRE PLASMA ACCELERATOR
Lockheed Aircraft Corp., Missiles and Space Division, Sunnyvale, Calif.
LMSD-418236 (TR)

A device that accelerates a plasma derived from an exploding wire to velocites of 8×10^6 cm/sec has been developed. A description of the experimental apparatus used and the results attained is given. A brief analysis of the accelerating forces and their dependence on circuit parameters is also presented.

757. BEAMED ELECTROMAGNETIC POWER AS A PROPULSION ENERGY SOURCE (TN)
Willinski, M. I.
ARS Journal, p. 601, August 1959

758. CONTROLLED FUSION RESEARCH—AN APPLICATION OF THE PHYSICS OF HIGH TEMPERATURE PLASMAS
Reviews of Modern Physics, v. 28, no. 3, pp. 338–362, 1956

759. ELECTRIC PROPULSION PROGRESS–CONSIDERABLE THEORETICAL WORK UNDERWAY
Stuhlinger, E.
Missiles and Rockets, v. 5, no. 30, pp. 83–87, July 20, 1959

760. ELECTRICAL PROPULSION SYSTEMS IN SPACE FLIGHT
Shepherd, L. R.
Astronautica Acta, v. 5, Fasc. 2, p. 144, 1959

761. ENERGY SOURCES FOR ROCKET ENGINES AND THEIR SPHERES OF APPLICATION
Vernet-Lozet, N.
Technique et Sciences Aeronautiques, France, no. 4, pp. 153–163, 1958

Three broad categories of energy supply are recognized: (1) thermo-chemical; (2) thermo-nuclear; (3) electro-nuclear. (1) is subdivided according to whether the energy derives from oxidation-reduction, catalytic decomposition, or reassociation in free radicals. Materials briefly reviewed include liquid oxygen, nitric acid, peroxide, liquid ozone, boranes, lithium hydride. Energy contents of propergols are formulated and some values given for other representative materials. (2) is discussed very briefly, (3) not at all. Relations between energy characteristics of the fuels and the application of the rocket are demonstrated. (*Index Aeronauticus*, February 1959)

762. EXPERIMENTAL INVESTIGATIONS OF PLASMA ACCELERATORS FOR SPACE VEHICLE GUIDANCE AND PROPULSION
Moses, K., et al.
General Electric Co., Missile and Space Vehicle Dept., Evendale, Ohio
Doc. R59SD466, November 23, 1959

A description is given of experimental studies concerning the possible application of a pulsed plasma accelerating device for space propulsion and attitude control. The particular laboratory model discussed employs an electric discharge to create a plasma which is electromagnetically accelerated into a high-vacuum chamber. A novel valve has been devised which serves the dual purpose of introducing the minute amounts of propellant required while obviating the need for external switching of the discharge.

763. EXPERIMENTAL RESULTS WITH A COLLINEAR ELECTRODE PLASMA ACCELERATOR AND A COMPARISON WITH ION ACCELERATORS
Kash, S. W. and Starr, W. L.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 1008-59

A collinear electrode plasma accelerator using either plasma derived from an exploding wire or from electrode erosion has been in operation for some time. This paper presents a discussion of particle velocities, I_{sp}, and computed efficiencies.

764. FOTONNYI KOSMICHESKII KORABL
Nesterenko, G.
Krylia Rodiny, pp. 16–17, October 1958 (in Russian)

General discussion covering the development of space travel and propulsion systems. Basic principles of photon rocket operation are included. (*A/SE*, August 1959)

765. IMPULSE FROM AN EXPLODING WIRE PLASMA ACCELERATOR
Starr, W. L.
Journal of Applied Physics, v. 30, no. 4, pp. 594–595, April 1959

766. A POWER SOURCE FOR SPACE FLIGHT
Business Week, no. 1575, pp. 107–110, November 7, 1959

767. PROTOTYPE MHD POWER SYSTEMS PRODUCES 1 kw
Missiles and Rockets, v. 5, no. 45, p. 36, November 2, 1959

768. NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION RESEARCH ON PLASMA ACCELERATORS
Moeckel, W. E. and Rayle, W. D.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 1005-59

Current NASA research on plasma accelerators is described, and future plans are briefly discussed.

769. ON MAGNETOHYDRODYNAMIC PROPULSION
Yoler, Y. A.
Proceedings of the American Astronomical Society, 4th Annual Meeting, January 29–31, 1958, New York, N.Y.

The need for a technique of propulsion intermediate to that of chemical and ionic propulsion is indicated from the point of view of propulsion efficiency. A simple theoretical model on magnetohydrodynamic propulsion on breathing and rocket engines is set up, and results are presented indicating the significant parameters and nature of magnetohydrodynamic power, and the feasibility of plasma propulsion.

770. ON MAGNETOHYDRODYNAMIC PROPULSION
Kantrowitz, A. and Janes, G. S.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 1009-59

This paper contains a discussion of the properties of plasma accelerators employing electrodes considered as circuit elements. It is shown that these devices have very low effective characteristic impedances, and that provision must always be made for recovery of the magnetic field energy before the plasma is expelled. These considerations, plus the assumption of electrode arc voltage drops, lead to a theorem relating the minimum instantaneous power, the efficiency, and the specific impulse.

771. OPTIMUM POWER GENERATION USING A PLASMA AS THE WORKING FLUID
(Gas Dynamics Symposium, Northwestern University, Evanston, Ill., August 24–26, 1959)
Neuringer, J. L.
American Rocket Society, New York, N. Y.
P-907-59

With the possibility of controlled thermonuclear fusion in the future, the question arises whether it would be possible to use the plasma itself as the working fluid to generate electric power by electro-magnetic induction. The problem considered in this paper is the steady one-dimensional motion of a plasma in a channel of arbitrary and slowly varying cross section. The extreme problem is formulated using the techniques of the calculus of variations to obtain the appropriate system of differential equations and boundary conditions.

772. PLASMA ENGINE DELIVERS NEARLY 2-lbs
Gettings, H.
Missiles and Rockets, v. 5, no. 24, pp. 34–36, June 8, 1959

773. PLASMA MOTORS
Bostick, W. H.
Proceedings of the American Astronautical Society, 4th Annual Meeting, January 29–31, 1958, New York, N.Y.

It has been demonstrated that plasma consisting of titanium ions, deuterium ions, and electrons can be propelled by a small button plasma gun at speeds up to 2×10^7 cm/sec. Plasma motors employing rails should be able to obtain speeds of 10^8 cm/sec without any difficulty. The corresponding specific impulse is 10^5 sec. Several types of plasma motors will be discussed.

774. PLASMA PROPULSION
Ducati, A. C. and Cann, G. L.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 1010-59

Spaceflight propulsion studies definitely indicate that for practically all space missions electrically driven rockets offer a substantial saving in mass over chemical rockets. Furthermore, if these studies are limited to satellites and Moon missions they show that the most advantageous

specific impulses are in the 2,000–3,000 sec range. Thus, the arc jet becomes definitely suitable for this kind of application. The results of the various phases of the program are presented and discussed following the same chronological sequence in which they were obtained.

775. PLASMA PROPULSION BY A RAPIDLY VARYING MAGNETIC FIELD
Klein, M. M. and Brueckner, M. A.
General Electric Co., Missile and Space Vehicle Dept., Evendale, Ohio
AF 24(647)-269, Doc. R59SD453, December 2, 1959

The motion of a plasma driven by a rapidly varying magnetic field from a stationary coil have been investigated for: (1) the diamagnetic case (ionization process ignored) and (2) non-diamagnetic case. For the diamagnetic case a series of solutions have been obtained; for the non-diamagnetic cases a typical example has been worked out.

776. PLASMA PROPULSION DEVICES FOR SPACE FLIGHT
Camac, M., et al.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-45, February 1959

The use of electrical propulsion for the higher orbits of space probes would greatly increase the size of the payloads which could be launched. In placing a communication satellite in a 24-hour stationary orbit at 22,500 miles, there is an additional advantage in the use of electrical propulsion in that it has a dual function in subsequently providing power for the communication system. In this report, an analysis is made of the more immediate space missions in order to specify requirements for the propulsion chamber. Also, a discussion of neutral plasma devices is given and the important limitations to their operation is discussed.

777. PLASMA PROPULSION OF SPACECRAFT
Camac, M.
***Astronautics*, v. 4, no. 10, pp. 31–33, 113–115, October 1959**

778. PROPULSION
Grey, J.
***Aviation Age*, v. 28, pp. 36–43, March 1958**
(*Jet Propulsion*, Technical Literature Digest, 1958)

779. PROPULSION ENGINEERING
Holmes, J.
***Missiles and Rockets*, v. 5, no. 47, p. 37, November 16, 1959**

780. PROPULSION PAR PLASMA ACCELERE
Geradin, L.
***Fusées*, pp. 15–25, June 1959 (in French) (16 ref.)**

Evaluation of the advantages of accelerated plasma propulsion in terms of its application to space vehicles. The survey of systems includes electrodynamic ion, thermodynamic plasma, and magnetodynamic plasma engines, as well as various energy sources. The basic operating principles, thrust, and certain design aspects of each system are discussed. (*A/SE*, September 1959)

781. PROPULSION SYSTEMS FOR SPACE FLIGHT
Dillaway, R. B.
***Aeronautical Engineering Review*, v. 17, no. 4, pp. 42–49, 52, April 1958**
(*Applied Mechanics Reviews*, 1959, #5253)

782. REDUCTION OF FLIGHT TIME AND PROPELLANT REQUIREMENTS OF SATELLITES WITH ELECTRIC PROPULSION BY THE USE OF STORED ELECTRICAL ENERGY
Camac, M.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-36, October 1959, AFOSR-TN-58-1013
(ASTIA AD-206,156)

Satellites having a lower thrust than the local gravitational forces are considered. Two types of missions are analyzed in detail, both in the gravitational field of the Earth: (1) a trip from a small to a large circular orbit and subsequent return to the Earth; and (2) navigation between orbits at low altitudes (e.g., interception and rendezvous problems).

783. SCIENCE SEARCHES FOR THE KEY TO FUSION POWER AND SPACE TRAVEL THROUGH MAGNETOHYDRODYNAMICS
Kulsrud, R.
Institute of Radio Engineers Student Quarterly, pp. 36–42, May 1959

Basic explanation of physical principles of magnetohydrodynamics and some possible applications. (*A/SE*, October 1959)

784. SOME REMARKS CONCERNING A MAGNETOHYDRODYNAMIC METHOD OF PROPULSION
Meyer, R. X.
Space Technology Labs., Inc., Physical Research Lab., Los Angeles, Calif.
R-GM-TR-0165-00544, December 22, 1958
AF 04(647)-165

A hypothetical method of propulsion is considered, which utilizes a light-weight propellant, to which heat is transferred from a fission reactor. A magnetohydrodynamic scheme is used which would allow it to reach an exhaust temperature in excess of the thermal limit set by reactor technology. Lower limits are derived for the required electrical conductivity of the plasma and for the pressure ratio of the device.

785. SPACE PROPULSION ENGINES–A PROBLEM IN PRODUCTION OF HIGH VELOCITY GASES
(Gas Dynamics Symposium, Northwestern University, Evanston, Ill., August 24–26, 1959)
Ghai, M. L.
American Rocket Society, New York, N. Y.
P-908-59

A basic problem of space propulsion engines is to generate gases at very high velocities–about 8 to 100 times the gas velocities generated by the conventional jet engines. Three electric propulsion engines inherently capable of producing the required velocities are presented–the electrothermal propulsion or the arc jet engine, the plasma propulsion or the magnetohydrodynamic engine, and the ion propulsion engine.

786. THE ADVANTAGES OF HIGH THRUST SPACE VEHICLES
Hunter, M. W. and Tschirgi, J. M.
American Rocket Society 14th Annual Meeting, November 16–20, 1959, Washington, D.C.
Paper 991-59

A comparison of high and low-thrust propulsion systems is made. Only missions shuttling from orbit to orbit are considered and the payload comparison analysis assumes single stage devices.

787. THE MAGNETIC PINCH ENGINE FOR SPACE FLIGHT
Kunen, A. E. and McIlroy, W.
American Astronautical Society, Western National Meeting, August 4–5, 1959, Los Angeles, Calif.
Preprint 59-13

MAGNETOHYDRODYNAMICS (MISCELLANEOUS)

788. IMPROVED MAGNETIC SUSPENSION SYSTEM
McIlwraith, C. G., Breazeale, J. B., and Dacus, E. N.
***Review of Scientific Instruments*, v. 29, no. 11, pp. 1029–1033, November 1958**

The apparatus supports a ferromagnetic object free from contact with its surroundings and is capable of maintaining this support for any attitude or orientation in space of the apparatus as a whole. Conditions for stable support are given and features of the system of potential use in instrumentation are described. (*PA*, 1959, #3086)

789. DESIGN AND OPERATION OF ELECTRO-MAGNETIC PUMPS. PARTS I, II
Veress, G.
***Energia es Atomtechnika*, v. 11, no. 7–8, pp. 474–484, July–August 1958; v. 11, no. 9–10, pp. 633–639, September–October 1958**

Author reviews the governing equations in their elementary forms both for the electromagnetic body forces and for hydraulics in pipes. In treating the design problem of pumps for liquid metals he uses the analogy with electrical engineering (both dc motor and induction motor analogies). (*AMR*, 1959, #6339)

790. FOURTH QUARTERLY ENGINEERING REPORT ON THE STUDY OF ELECTRO-MAGNETIC PHENOMENA FOR SPACE NAVIGATION
Franklin, R. G. and Birx, D. L.
Franklin Institute, Philadelphia, Pa. QR-A-A2183-4, June 1959, AF 33(616)-5898
(ASTIA AD-225,193)

From the viewpoint of total energy available, the optical wavelength region appears most suitable for Doppler determination with natural radiation. System studies using available radiation in this range indicate that an 8- or 10-in. telescope appears to be an optimum size. Design parameters for typical Doppler systems are presented, one employing a multiple slit technique to increase the signal level. For the spectra investigated, the optimum number of slits is about 10. Additional studies reported on briefly include an examination of molecular rotation lines predicted in radiation from outer space, molecular amplification at infrared and optical wavelengths and the Fabry-Perot interferometer for Doppler measurement.

791. AN INTRODUCTORY DISCUSSION OF MAGNETOHYDRODYNAMICS
Kantrowitz, A. R. and Petschek, H. E.
AVCO Manufacturing Corp., AVCO-Everett Research Lab., Everett, Mass.
Research R-16, May 11, 1957

The classification of domains of gaseous magnetohydrodynamics and the significance of this classification for the dynamics of ionized gases are discussed in addition to the general problem of the growing interest in this field.

792. APPLIED MAGNETO-HYDRODYNAMICS
***Transactions of the Institute of Physics of the Latvian Academy of Sciences*, v. 8, 1956**
AEC-TR-3602

793. CREATING THE CONDITIONS OF SPACE TRAVEL
Coates, V. J., Jr.
***Industrial Photography*, v. 8, no. 6, pp. 26–27, June 1959**

794. MAGNETO-HYDRODYNAMICS AND THERMONUCLEAR PROBLEMS
Alfvén, H.
Royal Institute of Technology, Stockholm
A/Conference 15/P/145

There are two different requirements for a thermonuclear reactor: (a) a plasma should be heated to a very high temperature and (b) the heated plasma should be confined during a sufficiently long time. In experiments of the ZETA type both these effects are produced in the same volume. From some points of view it may be an advantage to heat the gas in a volume which is separated from the volume where it is ultimately confined. This may be achieved by shooting a heated and magnetized plasma between cylindrical or conical electrodes towards a transverse magnetic field, which may be trapped by the plasma in such a way that one obtains a ring with a longitudinal magnetic field enclosed by an external field threading the hole in the ring. Theoretical and experimental investigations about the possibility of forming a plasma ring in this way are reported. Different methods to heat the plasma to extremely high temperatures are discussed. (*NSA*, 1959, #6552)

795. MAGNETOHYDRODYNAMICS–A SEMINAR
Journal of Scientific and Industrial Research, New Delhi, India, v. 17A, no. 5, pp. 194–196, May 1958
(*Applied Mechanics Reviews*, January 1959, #465)

796. MAGNETOHYDRODYNAMICS
Bulletin of the American Society for Testing Materials p. 62, February 1959
(*Applied Science and Technology Index*, v. 47, no. 6, June 1959)

797. MAGNETOHYDRODYNAMICS
Astronautics, v. 4, no. 11, pp. 40, 134–136, November 1959

798. BASIC FACTORS COMPLICATE PLASMA WORK
Butz, J. S.
Aviation Week, pp. 36–39, June 2, 1958
(*Pacific Aeronautical Library*, 1958, #25242)

799. INTRODUCING MAGNETOHYDRODYNAMICS
Kantrowitz, A. R.
Astronautics, v. 3, no. 10, pp. 18–21, October 1958
(*Applied Mechanics Reviews*, July 1959, #3634)

800. MAGNETOHYDRODYNAMICS OPENS UP NEW ELECTRONIC VISTAS
Stambler, I.
Space/Aeronautics, pp. 28–36, January 1959
(*Pacific Aeronautical Library*, 1959, #30770)

801. MAGNETOHYDRODYNAMICS
Steginsky, B.
Battelle Technical Review, v. 9, no. 2, pp. 3–9, February 1960

Magnetohydrodynamics offers possible solutions for problems associated with control of the thermonuclear reaction, propulsion of space vehicles, and hypersonic aerodynamics. The author discusses the fundamental mechanisms involved and describes possible methods for utilizing the new knowledge.

802. MAGNETOHYDRODYNAMICS IS AN OLD FIELD WITH NEW IMPLICATIONS FOR ENGINEERS
McIlroy, W.
Society of Automotive Engineers Journal, p. 90–93, April 1958
(*Pacific Aeronautical Library*, 1958, #24254)

803. MAGNETO-HYDRODYNAMICS OF FUSION
Alfvén, H.
Teknisk Tidskrift, v. 88, no. 36, pp. 917–918, October 1958 (in Swedish)
(*Applied Mechanics Reviews*, 1959, #4728)

804. MAGNETOHYDRODYNAMICS
Syrovatskii, S. I.
Uspekhi Fizicheskikh Nauk, SSSR, v. 62, no. 3, pp. 247–303, 1957 (in Russian)

The basic principles are reviewed, and all the fundamental equations are set out. The following are considered (but not with reference to Hg and other liquid metals); the propagation of small disturbances; rupture surfaces and shock waves; increase of magnetic field; the hydromagnetic dynamo; stability problems; magnetohydrodynamic turbulence. (*PA*, 1958, #5133)

805. MAGNETOHYDRODYNAMICS: HOPE FOR SPACE
Butz, J. S.
Aviation Week, May 12, 1958 (Also in *Space Technology*, p. 8–9, July 1958)

806. BOEING GROUPS PROBE SPACE TECHNIQUES
Sweeney, R.
Aviation Week, v. 71, no. 19, pp. 56–69, November 9, 1959

STELLARATOR

807. THE DIVERTOR, A DEVICE FOR REDUCING THE IMPURITY LEVEL IN A STELLARATOR

Burnett, C. R., et al.
***Physics of Fluids*, v. 1, no. 5, pp. 438–445, September–October, 1958**

The heavy ions released from the walls of the stellarator can be side tracked by a special magnetic device. This article contains a detailed discussion of the divertor, the various design problems, experimental procedures and some results. The impurity concentrations have been reduced by factors 2 to 3, perhaps even more in the core of the discharge. With the divertor the ion temperature has been increased from 40 ev to 60 ev for He, ionized once, and to 130 ev for O, ionized four times. (*AMR*, 1959, #2656)

808. "RUNAWAY" ELECTRONS AND COOPERATIVE PHENOMENA IN B-1 STELLARATOR DISCHARGES

Bernstein, W., et al.
***Physics of Fluids*, v. 1, no. 5, pp. 430–437, September–October, 1958**

An experimental and detailed investigation of X-ray radiation from a B-1 stellarator during pulsed discharge. The results cannot be explained by single-particle models or macroscopic plasma physics. The evidence suggests that "collective phenomena" do occur. The runaway electrons indicate the existence of instabilities at currents well below the Kruskal limiting current. Intense microwave radiation is also observed. (*AMR*, 1959, #2655)

809. THE STELLARATOR CONCEPT

Spitzer, L., Jr.
***Physics of Fluids*, v. 1, no. 4, pp. 253–264, July–August, 1958**

All the work dealing with the attainment of economic nuclear fusion and actively under way since about 1950 has recently been declassified. Project Matterhorn, located in Princeton, has been concerned with a discharge in a torus. High-temperature plasma is confined by means of a magnetic field. In order to avoid certain types of instability, the longitudinal lines of force produced by an external coil are spirally twisted in a prescribed way. The resulting device, known as the stellarator, had originally a figure-eight form, but later it proved possible to return to a single torus on producing an equivalent twist by means of auxiliary coils. After initial breakdown, complete ionization of the gas and heating is produced by a longitudinal electric current. Since this was found to have certain drawbacks, other methods of heating such as resonance absorption of microwaves are under active investigation.

The paper under review, written by the director of the project, expounds the basic principles of the magnetic confinement and heating to high temperatures of an ionized gas in a machine of this type. It forms the introduction to a quite lengthy series of papers contained in *Physics of Fluids*, v. 1, no. 4–5, 1958, in which a number of collaborators discuss a variety of theoretical and practical problems of the stellarator. This includes geometry of magnetic fields, problems of the stability of magnetically confined ionized gases, problems of heating by various methods, and parasitic phenomena and their prevention. (*AMR*, 1959, #2652)

810. EXPERIMENTS ON THE OHMIC HEATING AND CONFINEMENT OF PLASMA IN A STELLARATOR

Coor, T., Cunningham, S. P., Ellis, R. A., Heald, M. A., and Kranz, A. Z.
***Physics of Fluids*, v. 1, no. 5, pp. 411–420, September–October, 1958**

The basic concepts of confinement and ohmic heating in a figure-eight stellarator are briefly reviewed and relevant experimental data summarized. The production of energetic X-rays by runaway electrons, up to 10 msec after the disappearance of the accelerating field, has indicated effective single-particle confinement by the magnetic fields of 20,000 to 30,000 gauss. However, the plasma confinement time during ohmic heating appears to be limited by unknown processes to approximately 100 μsec

for hydrogen, more than three orders of magnitude shorter than predicted from classical collisional diffusion. The ionization level in a helium discharge, with an initial pressure of about 1 μ of Hg, becomes virtually complete during the heating pulse, and the electric resistivity corresponds to a kinetic temperature of about 100 v, or 10^5 deg. After the heating pulse, the electron density decays with a time constant as great as 6 msec under some conditions. The hydromagnetic kink instability predicted by Kruskal has been clearly observed.

811. HYDROMAGNETIC INSTABILITY IN A STELLARATOR

Kruskal, M. D., et al.
***Physics of Fluids*, v. 1, no. 5, pp. 421–429, September–October, 1958**

Authors investigate the stability of a column of plasma in the presence of a large magnetic field parallel to the column and its discharge current. For small perturbations, various helicoidal unstable modes are found. The external conductors have negligible effects on the stability of the column. In the case of the stellarator, a gradual twist of the cylindrical coordinates must be introduced. This leads to a critical discharge current for the appearance of helicoidal unstable motions. The experimental results are in good agreement with the theory for the first mode. The stability of higher modes is affected by the current distribution, and there is no evidence that they have serious effects. (*AMR*, 1959, #2654)

812. OHMIC HEATING IN THE B-1 STELLARATOR

Bernstein, W. and Kranz, A. Z.
***Physics of Fluids*, v. 2, no. 1, pp. 57–61, January–February, 1959**

A detailed comparison between experimental data and the predictions of ohmic heating theory is made over a wide range of axial magnetic confining field, electric heating field, and helium pressure. It is found that, in the early stages of the discharge, agreement between theory and experiment is good, and the predicted scaling laws are valid. However, experimentally it is found that it takes about five times longer to complete first ionization than predicted. Also, the current is seen to level off at a plateau at a time when theory predicts a continuous heating. These discrepancies are attributed to three energy sinks: cold neutral particles entering the discharge, runaway electrons leaving the discharge, and radiation from impurities. In addition, the electron density is observed to decrease during the length of the discharge (pump-out). For the early current plateau observed at low ratios of heating field to pressure, it appears that the plasma density is about 15 percent less at 18,000 gauss than at 27,000 gauss as a result of this pump-out. The hydromagnetic instability predicted by Kruskal and previously demonstrated to exist is given the physical characteristics of an increased rate of diffusion. (*PA*, 1959, #3601)

813. ON THE IONIZATION AND OHMIC HEATING OF A HELIUM PLASMA

Berger, J. M., et al.
***Physics of Fluids*, v. 1, no. 4, pp. 297–300, July–August, 1958**

A method for ionizing and heating helium plasmas in various stellarator configurations consists of inducing a near-constant electric field along the principal axis of the confining magnetic field. Assuming (1) the gas is 10 percent ionized at a temperature of a few electron-volts, (2) Maxwellian velocity distributions for the particles, and (3) a negligible charged particle loss across the magnetic field, the pertinent calculations and results are presented. In view of the assumptions the results are not precise but represent an interesting first-approximation. (*AMR*, 1959, #2093)

GENERATORS

814. DESIGN CONSIDERATION OF A STEADY DC MAGNETOHYDRODYNAMIC ELECTRICAL POWER GENERATOR

Sutton, G.
General Electric Co., Missile and Space Vehicle Division, Philadelphia, Pa.
G-E MSVD AL TIS R59SD432, September 15, 1959

USAF-supported evaluation of the design requirements of a steady, dc, magnetohydrodynamic electrical power generator. Expressions are derived for the generator power, size, efficiency, and magnet power. Losses due to heat transfer and electrical effects are calculated. Considerations of the Hall effect indicate that there is a relation between the pressure and magnetic field which yields the minimum length generator. (*A/SE*, January 1960)

815. MEASUREMENTS OF VELOCITY AND MOMENTUM WITH A PULSED T-TUBE PLASMA GENERATOR

Gorowitz, B. and Harned, B.
General Electric Co., Missile and Space Vehicle Division, Philadelphia, Pa.
Doc. R59SD314, Aerophysics Research Memo 26, February 20, 1959

In preliminary studies concerning the use of plasma acceleration for propulsion purposes, a series of measurements has been made of velocity and momentum of plasma bursts both in single-shot and pulsed operation over a range of pressures and input energies for various magnitudes and directions of magnetic field at the gaseous discharge. The effect of magnetic field on acceleration of the plasma and its contribution to the momentum transferred to a ballistic pendulum are discussed. Extrapolation has been made of power input for the small thrust obtained to that required for a one-pound thrust over the range of pressures and efficiencies investigated.

RELATIVISTIC HYDROMAGNETICS

816. RELATIVISTIC MAGNETOHYDRODYNAMICS
Goto, K.
Osaka University
***Progress of Theoretical Physics*, Kyoto University, Japan, v. 20, pp. 1–14, July 1958**

Starting with the relativistic Boltzmann transport equation, basic equations for relativistic magnetohydrodynamics of perfect and imperfect gases are derived. Relativistic magnetohydrodynamical generalizations of Kelvin's circulation theorem, Helmholtz's vortex theorem, and Rankine-Hugoniot's shock relations for the simple gas are also given. (*NSA*, 1959, #3165)

817. ON RELATIVISTIC THERMODYNAMICS
Balazs, N. L.
***The Astrophysical Journal*, p. 398, July–November, 1958**

In this note we derive the conditions for thermal equilibrium in the presence of gravitational fields using relativistic mechanics and the orthodox methods of thermodynamics.

818. SOME QUESTIONS IN RELATIVISTIC HYDROMAGNETICS
Zumino, B.
***The Physical Review*, v. 108, no. 5, pp. 1116–1121, December 1, 1957**

The basic equations describing the motion of an ideal relativistic fluid in the presence of electromagnetic fields are formulated both in their differential and in their integral form. From the integral equations shock conditions are derived. In the limit of weak shocks the velocities of propagation of the various kinds of shocks and the discontinuities of the various physical quantities are calculated. (*PA*, 1958, #1787)

819. RELATIVISTIC MAGNETOHYDRODYNAMICS
Harris, E. G.
***The Physical Review*, v. 108, no. 6, pp. 1357–1360, December 15, 1957**

The relativistic equations of motion for a conducting fluid in a magnetic field are formulated. A relativistically correct equation for the production of entropy due to joule heating is derived from the conservation laws for mass, momentum and energy. It is shown that both the energy density of the magnetic field and the magnetic pressure contribute to the inertia of a perfectly conducting fluid. The general dispersion relation for small-amplitude oscillations is found. (*PA*, 1958, #1788)

820. ON MAGNETOHYDRODYNAMIC WAVES AND MAGNETIC TANGENTIAL DISCONTINUITIES IN RELATIVISTIC HYDRODYNAMICS
Khalatnikov, I. M.
***Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki*, v. 32, no. 5, pp. 1102–1107, 1957 (in Russian)**

The problem of magnetohydrodynamic waves in relativistic hydrodynamics is discussed. Formulae are derived which yield the velocity of these waves in the presence of a magnetic field whose direction forms an arbitrary angle with the direction of propagation of the waves in a medium with an arbitrary equation of state. The properties of purely magnetic tangential discontinuities in relativistic hydrodynamics are also discussed. (*PA*, 1958, #1789)

821. RELATIVISTIC FIELD THEORY OF UNSTABLE PARTICLES
Matthews, P. T. and Salam, A.
***The Physical Review*, v. 112, no. 1, pp. 283–286, October 1, 1958**
(*ARS Journal*, Technical Literature Digest, October 1959)

822. RELATIVISTIC HYDRODYNAMICS FOR A CHARGED NONVISCOUS FLUID
Wei, C. C.
***The Physical Review*, v. 113, p. 1414, March 15, 1959**

The equations of relativistic hydrodynamics are derived from an alternative variational method and a generalized vorticity equation is obtained. (*NSA*, 1959, #14643)

COSMIC AND TERRESTRIAL APPLICATIONS

823. POSSIBLE HYDROMAGNETIC SIMULATION OF COSMICAL PHENOMENA IN THE LABORATORY

Bostick, W. H.

***Reviews of Modern Physics*, v. 30, pp. 1090–1094, July 1958**

A technique has been developed whereby ionized gas (plasma) can be projected, by magnetic forces, at speeds of 3×10^7 cm/sec through a vacuum region free from a magnetic field. The plasma has also been projected across magnetic fields in vacuum at speeds of 10^7 cm/sec. It is concluded that magnetohydrodynamic phenomena are being produced in the laboratory. (*NSA*, 1958, #17526)

824. PROCEEDINGS OF THE THIRD SYMPOSIUM ON COSMICAL GAS DYNAMICS, JUNE 24–29, 1958

***Reviews of Modern Physics*, v. 30, no. 3, pp. 905–1108, July 1958**

The following topics were covered through a number of reports: empirical studies of velocity field in, and related structure of, the interstellar medium; theoretical considerations on the production and dissipation of velocity fields in the interstellar medium; cooling and condensation of interstellar matter; kinematic structure of gas envelopes; conditions at the ionization and shock fronts in collisions of gas clouds; some general gas-dynamical problems.

825. SOLAR ATMOSPHERIC HEATING BY HYDRODYNAMIC WAVES

Piddington, J. H.

***Monthly Notices of the Royal Astronomical Society*, London, v. 116, no. 3, pp. 314–323, 1956**

Previous estimates of solar atmospheric heating by hydromagnetic waves (due to joule loss and viscosity) showed negligible heating. A new mechanism is described, involving neutral atoms, which leads to absorption (and heating) many orders of magnitude greater than previously believed. If hydromagnetic waves are present they must cause strong heating effects. The formation of such waves from granules is described, their absorption at low levels, and partial reflection being discussed in some detail. A very rough order-of-magnitude estimate of energy flow is obtained. The region in which heating effects are important is restricted to the transition zone between lightly ionized and fully ionized gas. The energy absorbed in this region is estimated as being $\sim 10^5$ erg cm^{-2} sec^{-1}. Numerous particles with energies ~ 100 ev are released in this region and these may account for the quiet (non-spot) corona. The mechanism is likely to be important in connection with sunspot heating and flares and perhaps also interstellar hydromagnetic waves and cosmic ray generation. (*PA*, 1958, #857)

826. THE EQUILIBRIUM OF A SELF-GRAVITATING INCOMPRESSIBLE FLUID SPHERE WITH MAGNETIC FIELD

Bhatnagar, P. L.

***Journal of the Indian Institute of Science*, Section A and B, v. 40, pp. 50–73, April 1958**

Equations of equilibrium of a self-gravitating incompressible fluid and electromagnetic Maxwell's equations, in the steady case, are used to study the problem of magnetic fields that can prevail in an axisymmetric configuration. A new class of axisymmetric magnetic fields is characterized and the following special types are studied: force-free, poloidal, toroidal, and combination of toroidal and poloidal fields. The paper relates to the problem of magnetic stars. (*AMR*, 1959, #3103)

827. VELOCITY FIELDS IN A CORONAL REGION WITH A POSSIBLE HYDROMAGNETIC INTERPRETATION

Billings, D. E.

***The Astrophysical Journal*, p. 215, July 1959**

The distribution of λ 5303 half-widths in a coronal region shows an oscillatory pattern. This pattern, and the correlated gross Doppler displacements of the line, may

arise from a transverse hydromagnetic wave in the corona. Longitudinal hydromagnetic waves are also considered, but they appear less consistent with observations than transverse waves. Magnetic field perturbations of 0.05 gauss in a 1-gauss field are adequate to explain the pattern.

828. VLASOV INSTABILITY IN LONGITUDINAL PLASMA OSCILLATIONS

Auer, P. L.

***Physical Review Letters*, v. 1, no. 11, pp. 411–413, December 1, 1958**

Deduces a criterion for stability and a necessary condition for instability in a fully ionized plasma. The criterion is considered to have valid application to solar plasmas. (*PA*, 1959, #2443)

829. ATMOSPHERIC MAGNETIC FIELDS ABOVE ACTIVE SOLAR REGION OF APRIL 13, 1950

Correll, M. and Roberts, W. O.

***The Astrophysical Journal*, p. 726, January–May, 1958**

The authors have analyzed a period of well-observed prominence activity over a clear-cut active region at central meridian passage (CMP) on April 13, 1950, at N.13° heliographic latitude. Good-quality Climax west-limb prominence films in Hα revealed that the region had an associated homogeneous field of motions that extended from the region to more than 7×10^4 km. We found that the trajectories could be well described by assuming that they lay along the lines of force of a magnetic dipole buried 0.03 solar radii below the solar surface, with its axis tilted $\pm 50°$ from the plane of projection. The projection of the axis was approximately radial. There is evidence that a solar radio-noise storm at meter wavelength was associated with the region and was emitted parallel to the dipole axis rather than in a radial direction from the active region. There was also a geomagnetic disturbance so timed that it may well have resulted from solar corpuscles also emitted parallel to the dipole axis, at the same large angle from the solar radius.

830. THE FLOW ABOUT A CHARGED BODY MOVING IN THE LOWER IONOSPHERE

Hunziker, R. R.

CONVAIR, San Diego, Calif.

Physics Section Report Zph-033, April 1, 1959 (25 pp., 20 ref.)

Analysis using a simple gas model composed of electrons, ions, and neutral particles; a hydrodynamic description is given on the basis of Maxwell's transfer equations for a mixture. The conditions under which local statistical equilibrium can be assumed are discussed, and different approaches to determine the gas dynamic force in the subsonic, supersonic, and hypersonic cases are indicated. The reciprocal action of the flow electric field on the body is also analyzed, and a formula for the resultant electric force is given. Also includes calculation of the negative potential acquired by a plane body, and discussion of the solution of the external nonlinear problem which characterizes the electric potential and the electron distribution. (*A/SE*, January 1960)

831. PLASMA DYNAMICAL DETERMINATION OF SHOCK THICKNESS IN AN IONIZED GAS

Parker, E. N.

***The Astrophysical Journal*, v. 129, no. 1, pp. 217–223, January 1959**

It is shown that the principal interaction in a shock front in a tenuous ionized gas is a plasma interaction in which the ions transfer their translational energy to the plasma oscillations. The effect is, of course, of interest in auroral theories and in solar radio noise. It turns out to be the dominant effect in determining shock thicknesses nearly everywhere that the gas density is less than the solar photospheric value of 10^{16} atoms/cm^3. It is estimated that shock thicknesses in interstellar H II regions and in interplanetary space will be 1 km or less, even though the mean free paths may be 10^8 km or more and the ion Larmor radius $\sim$100 km. (*PA*, 1959, #4734)

832. A DYNAMO THEORY IN THE IONOSPHERE

Hirono, M. and Kitamura, T.

***Journal of Geomagnetism and Geoelectricity*, v. 8, no. 1, pp. 9–23, March 1956**

The differential equations of the dynamo theory are solved by numerical integration, taking into account the daily variation of the anisotropic conductivity. It is shown that the observed wind velocities in the E-region satisfy the requirements of the dynamo theory. The drift of the ionization is discussed, and it is shown that at night some of the electrons in the lower F-region will descend into the E-region in the middle latitudes. (*PA*, 1959, #947)

833. DYNAMICAL INSTABILITY IN AN ANISOTROPIC IONIZED GAS OF LOW DENSITY

Parker, E. N.

***The Physical Review*, v. 109, no. 6, pp. 1874–1876, March 15, 1958**

It is shown that when the thermal motions of a tenuous ionized gas are sufficiently anisotropic, the gas, and the initially uniform magnetic field which the gas is assumed to contain, become unstable. One mode of instability occurs when the gas pressure is greater parallel to the field than perpendicular, and another mode when the pressure is greater perpendicular than parallel. It is suggested that such instabilities may be of astrophysical interest, particularly with regard to the configuration of the solar dipole field as it is drawn out into interplanetary space by ionized gas from the Sun. (*PA*, 1958, #2425)

834. COSMICAL ELECTRODYNAMICS

Piddington, J. H.

***Proceedings of the IRE*, v. 46, no. 1, pp. 349–355, January 1958**

The spectacular results of radioastronomy have increased interest in the broader field of electromagnetic phenomena in cosmical physics. This subject is introduced here by a discussion of the various possible types of disturbance which may propagate in a magneto-ionic medium. The results are then applied in some regions of interest, particularly those from which nonthermal radio emission takes place. In the solar atmosphere many otherwise mysterious phenomena are explained as electromagnetic effects: the heating of the corona to 10^6 °K, flares, the violent motion of the gases and emission of radio waves, as well as X-rays and the corpuscles which cause magnetic storms. Interstellar space, the interior of a mysterious nebula and radio source (the Crab nebula), and interplanetary space provide more examples of electromagnetic phenomena. One of the most fundamental problems concerns the origin of cosmic rays, now believed to result from electromagnetic processes. Evidence is provided of an even more fundamental process: the creation of magnetic field on such an enormous scale that nuclear energy sources are indicated. (*PA*, 1958, #1413)

835. DYNAMICS OF THE INTERPLANETARY GAS AND MAGNETIC FIELDS

Parker, E. N.

***The Astrophysical Journal*, p. 664, July–November, 1958**

We consider the dynamical consequences of Biermann's suggestion that gas is often streaming outward in all directions from the Sun with velocities of the order of 500–1500 km/sec. These velocities of 500 km/sec and more and the interplanetary densities of 500 ions/cm^3 (10^{14} gm/sec mass loss from the Sun) follow from the hydrodynamic equations for a 3×10^6 °K solar corona. It is suggested that the outward-streaming gas draws out the lines of force of the solar magnetic fields so that near the sun the field is very nearly in a radial direction. Plasma instabilities are expected to result in the thick shell of disordered field (10^{-5} gauss) inclosing the inner solar system, whose presence has already been inferred from cosmic-ray observations.

836. DISTORTION OF A TOROIDAL FIELD BY CONVECTION

Allan, D. W. and Bullard, E. C.

***Reviews of Modern Physics*, v. 30, no. 3, p. 1087, July, 1958**

The effect of convective motions on an initially toroidal (i.e., horizontal) field near the surface of a fluid of finite conductivity has been studied in some simple cases by an approximate analytical method. It is found that the time to reach equilibrium is very long indeed, but apparently a loop of field is pushed outside the fluid fairly quickly. The result gives a possible explanation of the large changes observed in sunspot and terrestrial fields. (*PA*, 1959, #1603)

837. ELECTRICALLY CHARGED BODIES MOVING IN THE EARTH'S MAGNETIC FIELD

Fain, W. W. and Greer, B. J.

***ARS Journal*, p. 451, June 1959**

838. PROPAGATION OF ELECTROMAGNETIC PULSES AROUND THE EARTH

Levy, B. R. and Keller, J. B.

New York University, Institute of Mathematical Sciences, Division of Electromagnetic Research, N. Y.

Research R-EM-102, February 1957

AF 19(604)-1717, AFCRC-TN 57-380

(ASTIA AD-117,082)

The propagation of electromagnetic pulses around the Earth is investigated analytically. The pulses are assumed to be produced by a vertical electric or magnetic dipole. The Earth is treated as a homogeneous sphere of either finite or infinite conductivity and the atmosphere is assumed to be homogeneous. The results are represented as products of several factors, which are called the amplitude factor, the pulse-shape factor, the time-dependent height-gain factor for the source and receiver, and the conductivity factor.

839. SHOCK WAVES IN INTERSTELLAR SPACE. III. GASOMAGNETIC DISCONTINUITIES

Kaplan, S. A.

***Astronomicheskii Zhurnal*, v. 34, no. 3, pp. 321–327, 1957 (in Russian)**

Formation of magnetic-field discontinuities which are connected with shock waves is studied. It has been assumed up to now that when the gas passes over a magnetic discontinuity the full flow of energy is conserved (e.g. R. Lüst, *PA*, 1955, #5523). In the present paper the case is considered where luminescence occurs and the above condition does not hold. (*PA*, 1958, #5580)

840. EXAMPLES OF GAS MOTION AND CERTAIN HYPOTHESES ON THE MECHANISM OF STELLAR OUTBURSTS

Sedov, L. I.

***Reviews of Modern Physics*, v. 30, no. 3, pp. 1077–1079, July 1958**

Some exact solutions of the equations of gas dynamics are presented: (1) a spherically symmetric radial motion of a self-gravitating gas with $\gamma = 7/6$, in which a shock wave of radius $\propto t^{5/6}$ expands into a stationary region. The energy of the motion is constant. (2) A cylindrically symmetric unsteady radial motion of a conducting gas in a magnetic field. The solution contains one arbitrary function if there is no self-gravitation, and seven arbitrary constants if there is self-gravitation. (3) A steady, cylindrically symmetric supersonic motion of a conducting gas deflected by a magnetized cone. All the magnetic field is pushed into a stagnant region next to the cone, separated from the flowing gas by a conical surface.

841. GALACTIC TURBULENCE AND THE ORIGINS OF COSMIC RAYS AND THE GALACTIC MAGNETIC FIELD

Piddington, J. H.

***Australian Journal of Physics*, v. 10, no. 4, pp. 515–529, December 1957**

A new absorption mechanism is discussed in relation to the turbulence of the interstellar gas in the presence of a magnetic field. It is evaluated and compared with ordinary viscous absorption in different types of interstellar gas. Wherever there is a proportion, even though very small, of neutral atoms (helium being most likely) the new mechanism predominates for waves if length comparable with one parsec or more. The fact that hydromagnetic shear waves, either traveling or standing waves, of length about one parsec are heavily damped provides evidence against Fermi's theory of cosmic rays. The new difficulty must be faced for any of the recent formulations of the theory, only being absent when the gas is fully ionized. The mechanism also raises additional difficulties in explaining the observed irregular motion of the HI gas clouds. The rate of dissipation of magnetic energy is found the same for hydromagnetic waves and for non-oscillatory distortions of the field; even for a field in a solid conductor. The dissipation time depends only on the conductivity and the size of the irregularities in the field. Theories of spontaneous growth of magnetic fields are discussed critically and a minimum criterion of growth is suggested. (*PA*, 1958, #4624)

842. GEOMAGNETIC PULSATIONS AND THE EARTH'S OUTER ATMOSPHERE

Obayashi, T. and Jacobs, J. A.

***Geophysical Journal of the Royal Astronomical Society*, v. 1, no. 1, pp. 53–63, March 1958**

Hydromagnetic oscillations of the Earth's ionized outer atmosphere along the geomagnetic lines of force are considered. The observational evidence of world-wide geomagnetic pulsations yields the distribution of ionic density in the outer atmosphere extending beyond the ionosphere. It is found that the ion density is about 10^3 per cm^3 at a distance of a few Earth radii decreasing exponentially to a value of the order of 5 per cm^3 in interplanetary space. A theoretical consideration of the temperature of the outer ionosphere is also discussed. (*PA*, 1958, #3604)

843. TIME VARIATION OF THE INTENSITY OF AURORAL HYDROGEN EMISSION AND THE MAGNETIC DISTURBANCE

Fan, C. Y.
***The Astrophysical Journal*, p. 420, July–November, 1958**

The time variation in the intensity of auroral hydrogen emission and the magnetic disturbance were simultaneously recorded for a number of cases at the Yerkes Observatory. It was found that the horizontal component of the terrestrial magnetic field increases prior to the appearance of an auroral arc and that the onset of a negative bay in the disturbance coincides with the breakup of the arc to rays and an abrupt decrease in the intensity of the hydrogen emission. These observations suggest that there are two current systems—one responsible for the acceleration of auroral protons and electrons for the excitation of auroral arcs and the other for the acceleration of auroral electrons for the excitation of auroral displays of more active types.

844. HYDROMAGNETIC WAVES IN A HORIZONTALLY STRATIFIED ATMOSPHERE

Ferraro, V. C. A. and Plumpton, C.
***The Astrophysical Journal*, v. 127, no. 2, pp. 459–476, March 1958**

The propagation of hydromagnetic waves in a horizontally stratified atmosphere is of interest in connection with theories of sunspot magnetic fields and coronal heating. The problem was briefly discussed by Ferraro (1954), who assumed that both the particle velocity and the magnetic field variations were perpendicular to the magnetic field. The resulting motion is a simple Alfvén or *A*-wave, in which there is equipartition of kinetic and magnetic energy. In this paper the more general case is considered taking account of the compressibility of the gas. The associated waves, which may be termed "*S*-waves," are such that the particle velocity and magnetic-field variations have both horizontal and vertical components. They are of two main types, and, if the frequency is large, one of them is similar to an *A*-wave and the other behaves effectively as a sound wave. The *A*-type wave is characterized by the fact that the vertical components of the velocity and magnetic field variations are negligible. (These *S*-waves and *A*-waves are the analogues of the modified sound and Alfvén waves first discussed by van de Hulst, 1951). This corroborates Cowling's conclusion that gravity will tend to inhibit vertical motions in a hydromagnetic wave, and, *ipso facto*, lends support to Cowling's criticism of Alfvén's theory of sunspots. The bearing of the result on the propagation of hydromagnetic waves in the solar chromosphere and corona is discussed, and it is tentatively suggested that the solar spicules may be explained on the basis of the sonic type of *S*-waves. (*PA*, 1958, #2430)

845. OBSERVATIONS OF EXPLOSIONS OF HIGH-SPEED PLASMA IN A MAGNETIC FIELD

Bostick, W. H.
***The Astrophysical Journal*, p. 237, January–May, 1958**

846. LARGE AMPLITUDE HYDROMAGNETIC WAVES ABOVE THE IONOSPHERE

Dessler, A. J.
***Journal of Geophysical Research*, v. 63, no. 3, pp. 507–511, September 1958**

Arguments are presented for the existence above the ionosphere of very large amplitude hydromagnetic waves. Crude estimates show that it is not unreasonable to expect hydromagnetic waves above the ionosphere to have an amplitude of the order of 10^2 times the amplitude of geomagnetic fluctuations observed at the surface of the Earth. It is suggested that these hydromagnetic waves produce the irregularities in electron density which are responsible for radio-star scintillation. It is also suggested that the large amplitude hydromagnetic waves are responsible for producing the high-intensity particle radiation observed above about 1000 km by Van Allen, et al. (*PA*, 1959, #3013)

847. LARGE-AMPLITUDE HYDROMAGNETIC WAVES ABOVE THE IONOSPHERE

Dessler, A. J.
***Physical Review Letters*, v. 1, no. 2, pp. 68–69, July 15, 1958**

Hydromagnetic waves are assumed to be generated by variations in the density or velocity of the ionized coronal gas at the edge of the Earth's dipole field (at 6–10 Earth radii). These waves will be propagated downward and the variation of velocity with altitude is discussed. They may be observed at the surface of the Earth as fluctuations in the geomagnetic field. (*PA*, 1958 #7630)

848. MAGNETOHYDRODYNAMIC SHOCK WAVES IN THE SOLAR CORONA, WITH APPLICATIONS TO BURSTS OF RADIO-FREQUENCY RADIATION

Westfold, K. C.

***The Philosophical Magazine*, Eighth Series, v. 2, pp. 1287–1302, November 1957**

It is pointed out that the Type II burst velocities which are usually associated with the velocities of streams of "auroral" particles should rather be associated with the velocities of the shock fronts ahead of such streams. Likewise, the far greater Type III burst velocities can be associated with the shock velocities of corpuscular streams having similar velocities, if it is possible to raise the local value of the sound velocity to the magnitude of the Type III estimates. This can be effected if local magnetic fields of some hundreds of gauss are present in the solar corona, resulting in a predominant magnetohydrodynamic component in the sound velocity. Starting from a set of transport equations previously investigated for an ionized gas, it is shown that in quasi-static electromagnetic fields the coronal medium satisfies an adiabatic equation of state and that the magnetic field lines are effectively "frozen" into the medium. The details of the transition across the shock front ahead of a stream in which all physical quantities depend only on the coordinate in the direction of flow is investigated for the case where the stream velocity is small compared with the sound velocity, and the results are compared with those for the hydrodynamic shock associated with a Type II burst. The coronal conditions and the excitation of radiation near the shock front are briefly discussed. (*PA*, 1958, #859)

849. MAGNETO-HYDRODYNAMIC WAVES IN THE IONOSPHERE AND THEIR APPLICATION TO GIANT PULSATIONS

Lehnert, B.

***Tellus*, v. 8, no. 2, pp. 241–251, May 1956**

In magnetohydrodynamics conservation of energy leads to the adiabatic relation, $du = pd\,\rho/\rho^2$, between the internal energy u per unit mass, the pressure p, and the density ρ. The relation is valid for arbitrary amplitudes in a non-dissipative medium. The Hall current modifies the properties of magnetohydrodynamic waves in an ionized gas. The compressive modes and the Alfvén mode earlier discussed by van de Hulst are shown to be coupled by means of the Hall current. The dissipation of slightly damped waves is expressed in terms of the effective conductivity $\sigma_3 = \sigma_1 + \sigma_2^2/\sigma_1$ earlier introduced by Cowling. The theory is applied to magnetohydrodynamic oscillations in the layers of the ionosphere. The possible periods of the waves are consistent with the periods of "giant pulsations" which have been observed as a type of perturbation in the Earth's magnetic field in the auroral zone. The results indicate that magnetohydrodynamic waves in the E-, F1-, and F2-layers may explain the existence of giant pulsations as well as the occurrence of rapid vibrations in the terrestrial magnetic field. (*PA*, 1958, #8548)

850. NOTE ON HYDROMAGNETIC WAVES PASSING THROUGH AN ATMOSPHERE WITH A DENSITY GRADIENT

Weymann, R. and Howard, R.

***The Astrophysical Journal*, v. 128, no. 1, pp. 142–145, July 1958**

A brief report of an investigation into wave propagation in a polytropic atmosphere overlaid by an isothermal atmosphere in the presence of uniform gravitational and magnetic fields. Results are given for "quasi-acoustic" and "quasi-Alfvén" waves. (*PA*, 1958, #8935)

851. ON SOME MAGNETOHYDRODYNAMICAL MOTIONS OF COSMOLOGICAL INTEREST IN A ROTATING CYLINDRICAL FLUID MASS

Agostinelli, C.

***Atti dell' accademia delle scienze di Torino I*, v. 90, no. 2, pp. 479–508, 1955–1956 (in Italian)**

The magnetic intensity and fluid velocity components for a uniform conducting liquid are expressed in terms of two scalar functions V and W which do not involve the axial coordinate z. V and W are expressed in the form

$$V = -\tfrac{1}{2}\,h_0 r^2 + \Psi\,(r, \phi, t),$$

$$W = -\tfrac{1}{2}\,\omega r^2 + \alpha\Psi\,(r, \phi, t),$$

where ω is angular velocity about the z-axis, and h_0 and α are constants. General solutions are obtained for the following cases (1) $\Delta_2\Psi = 0$ with α arbitrary; (2) $\alpha^2 = \mu/4\pi\rho$; (3) $\Delta_2\Psi = k\Psi$. It is suggested that the solutions obtained may have applications in the theory of the structure of spiral nebulae. (*PA*, 1959, #1597)

852. O VZAIMODEISTVII POTOKOV PROVODIASHCHEI SREDY S MAGNITNYM POLEM ZEMLI
Zhigulev, V. N. and Romishevskii, E. A.
Academiia Nauk SSSR, Doklady, pp. 1,001–1,004, August 11, 1959 (in Russian)

Investigation covering the motion of the Earth along a trajectory passing through the interplanetary ionized gas, as well as the interaction between corpuscular solar fluxes and the terrestrial magnetic field. The effect of possible collective interactions of particles, as well as the effect of mutual influence between the flow of ionized gas and the terrestrial magnetic field, are taken into account. The available data on the interplanetary matter in the vicinity of the Earth are surveyed, and the magnetohydromechanical approximation is used, assuming the medium to be an ideal continuum. Using previously obtained results, it is concluded that the interaction can be reduced to the study of the magnetic pinch phenomenon. (*A/SE*, December 1959)

853. PLASMA MOTIONS INDUCED BY SATELLITES IN THE IONOSPHERE. APPENDIX—DAMPING WHEN THE DENSITY IS HIGH
Kraus, L. and Watson, K. M.
Physics of Fluids, pp. 480–488, November–December, 1958 (12 ref.)

Analysis of the electrohydrodynamic phenomena associated with the high-velocity motion of a charged body in a plasma. It is shown that the effect of the electric field due to the charge on the body in inducing collective motion leads to similar results both for high- and low-density gases. By using a linearized theory, formulas are obtained for the electrohydrodynamic drag and for the increased ionization in the Mach cone behind the body. (*A/SE*, March 1959)

854. PARTICLE ENERGIES AND MAGNETIC ENERGY IN THE CRAB NEBULA
Burbridge, G. R.
The Astrophysical Journal, p. 48, January–May, 1958

Some difficulties associated with the estimates of the probable values of the particle and magnetic energies in the model of the Crab proposed by Oort and Walraven are discussed. To overcome these, a model is described in which the high-energy electrons and positrons necessary to explain the synchrotron emission are secondary particles which are produced following nuclear collisions of a primary proton flux. It is found that the total energy in this proton flux must amount to $\sim 5 \times 10^{50}$ ergs, while the continuously replenished flux of electrons and positrons, which have mean lives of only about 1–5 years, amounts to $1\text{–}5 \times 10^{46}$ erg. The magnetic field in the nebula is then $\sim 3 - 1 \times 10^{-2}$ gauss. Though the total energy is much greater than that proposed in the Oort-Walraven model, the difficulties of acceleration and continuous replenishment of the electron positron flux are thereby overcome. It is pointed out that the current radioactive energy input of the Crab is probably negligible in comparison with this total energy, which must have been derived from the initial explosion of the supernova.

855. NOTE ON HYDROMAGNETIC WAVES PASSING THROUGH AN ATMOSPHERE WITH A DENSITY GRADIENT
Weymann, R. and Howard, R.
The Astrophysical Journal, p. 142, July–November, 1958

856. ON THE TRANSFERENCE OF ANGULAR MOMENTUM BY HYDROMAGNETIC WAVES IN A PRIMEVAL NEBULA
Kendall, P. C.
The Astrophysical Journal, p. 194, January 1959

In this paper we consider a mechanism whereby angular momentum is transferred from one highly conducting region to another by hydromagnetic waves through an ambient magnetic field. We consider as a preliminary the transfer of linear momentum by hydromagnetic waves between one region of initially moving ionized gas and another region of initially stationary ionized gas. This will be unaffected after a time if the two regions are separated by a gas of very low density. The critical ratio is derived of the dimensions and density of the two regions that determines whether or not the initially stationary ionized gas can acquire most of the linear momentum. Using these exact results for comparison, an investigation is made by an order-of-magnitude argument of the corresponding problem of a primitive Sun with a magnetic field rotating in an infalling cloud of ionized gas or a solar nebula. The processes could have occurred during the formation of the solar system, but Alfvén's theory (1954) appears to require a much larger field for the primitive Sun than if we assume larger densities for the solar nebula. An obliquely rotating dipole is more favorable to the process than an axially symmetric one.

857. ELECTROMAGNETIC PROPERTIES OF A WHIRLING STELLAR PLASMA

Chovjkova, E.

***Byulleten' Astronomicheskikh Institutov Chekhoslovakii*, v. 8, no. 2, pp. 42–45, 1957 (Translated from *Referativnyi Zhurnal Fiziki*, no. 3, 1958, Abstract no. 6687)**

The electromagnetic properties formed in a quasi-neutral "whirling" plasma having an excess charge of one polarity, although a small one, are examined. The effects that are capable of reinforcing the magnetic field in such a "whirl" are investigated. Two extreme cases are considered: where the charged particles can penetrate beyond the limits of the "whirl," and when the displacement of the particles is confined to within slight dimensions. In the former case it is possible for radiation to occur within a certain frequency band. In the second case the ends of sufficiently long whirls can acquire, under special conditions, opposite magnetic polarities and opposite charges. On the basis of the theory considered, attempts are made to explain the occurrence of solar activity, radio waves from sunspots, and strong magnetic fields in certain stars. (*NSA*, 1959, #2079)

GENERAL REVIEW

858. PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT THE NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.
Princeton University, N. J., Project Matterhorn
TID-7558, February 3–5, 1958

(Abstracted in *Nuclear Science Abstracts*, 1959, #1210, #5398, #5408)

859. ON THE INTERACTION OF ELECTROMAGNETIC WAVES WITH CHARGED PARTICLES AND ON THE OSCILLATIONS OF THE ELECTRONIC PLASMA
Akhiezer, A. I.
***Il Nuovo Cimento*, Italy, v. 3, Series 10, Supplement no. 4, pp. 591–613, 1956**

The following subjects are considered: polarization energy loss and Cerenkov radiation in dielectrics and magnetics; penetration of a charged particle through electronic plasma; Cerenkov and Doppler effects in composite systems; the interactions of a beam of charged particles with slow electromagnetic waves; propagation of a beam of charged particles through electronic plasma; the longitudinal plasma oscillators in external fields; scattering of electromagnetic waves by plasma oscillations; and the non-linear wave motions in plasma.

860. LONG-RANGE INTERACTIONS IN IONIZED GASES IN THERMAL EQUILIBRIUM
Kahn, F. D.
***The Astrophysical Journal*, v. 129, no. 1, pp. 205–216, January 1959**

Collective long-range interactions affect the distribution of the charged particles belonging to a plasma in thermal equilibrium. The charge density can be expressed in terms of spatial Fourier components; when this is done, it is found that at a finite temperature the components of low wave-number k have an amplitude proportional to k^2, while in a random distribution the amplitude is independent of k. The components of large wave-number remain unaffected, the critical wave-number being of the order $(4\pi\Sigma\epsilon^2N/kT)^{1/2}$, where the summation extends over all particles in a typical unit volume. The partial ordering thus introduced may be important when the charged particles act together coherently. Thus, for example, it brings about a reduction in the scattering cross section, per electron, for electromagnetic radiation. (*PA*, 1959, #4733)

861. HIGH-FREQUENCY GAS-DISCHARGE BREAKDOWN (This Report Is Identical With Material Prepared for "Handbuch der Physik," v. XXII, 1955)
Brown, S. C.
Massachusetts Institute of Technology, Research Laboratory of Electronics, Cambridge
TR-301, July 25, 1955
Commerce Dept., Office of Technical Services
PB-123,212

An attempt is made to summarize knowledge of high-frequency gas discharge breakdown. The types of processes include diffusion-controlled, mobility-controlled, and electron-resonance breakdown, as well as breakdown phenomena in the presence of magnetic and dc electric field superimposed on the high-freqeuncy field.

862. I—CONTRIBUTO ALLA MAGNETOFLUIDODINAMICA
Napolitano, L. G.
II—ALCUNE CONSIDERAZIONI SULLA MAGNETOFLUIDODINAMICA DEI GETTI
Napolitano, L. G. and Pozzi, A.
***Missili*, pp. 15–34, February 1959, pp. 17–19, June 1959 (in Italian)**

Evaluation of the magnetohydrodynamic concept in terms of its range of applicability, including a survey of

available data and future possibilities. Analysis of the relative importance of three classes of phenomena is presented, covering phenomena on the macroscopic scale (determination of the convective motion of velocity v); phenomena on the microscopic scale (determination of the transport processes in the molecular scale); and phenomena due to the interaction of hydrodynamic and electromagnetic fields. Also included in the survey are: derivation of equations for the hydrodynamic and the electromagnetic fields; transformation of fundamental systems comprising entropy equations; dimensional analysis; and magnetohydrodynamics of plasma jets. (*A/SE*, December 1959)

863. A REVIEW OF MAGNETO-HYDRODYNAMICS
Yoler, Y. A.
Boeing Airplane Co., Scientific Research Laboratories, Seattle, Wash.
Doc. D1-82-0027, R-14, October 1959

This report is primarily a condensed review of the basic processes involved in certain classes of problems of engineering interest in fluid dynamics in situations where MHD effects are important.

864. RE-ENTRY PHYSICS PROGRAM SEMI-ANNUAL TECHNICAL SUMMARY REPORT TO THE ADVANCED RESEARCH PROJECTS AGENCY
(Period covered: October 1, 1958–June 30, 1959)
Massachusetts Institute of Technology, Lincoln Lab., Lexington
AF 19(604)-4559, Semiannual TSR–1, October 8, 1959

The principal objectives of the current program are: to determine the effects of the ionization produced by a re-entering body on the electromagnetic scattering characteristics of the body; to determine the effects of the ionization produced by a re-entering body on the transmission of electromagnetic radiation from sources in the body; to measure the intensity and the spectrum of electromagnetic and optical radiation resulting from the re-entry process; to develop adequate theoretical models for the experimentally observed phenomena and to correlate the experimental data with measurements obtained by laboratory methods.

865. RESEARCH INVESTIGATION DIRECTED TOWARD EXTENDING THE USEFUL RANGE OF THE ELECTROMAGNETIC SPECTRUM
(Period covered: June 16–September 15, 1957)
Kusch, P.
Columbia University, Radiation Laboratory, New York
QPR-7, September 15, 1957
DA-36-039-SC-64630

The sections of this report deal with: the generation of high frequencies, microwave apparatus and techniques, tube fabrication techniques, microwave physics, atomic hyperfine structures, and molecular and atomic properties.

866. SERIES OF LECTURES ON PHYSICS OF IONIZED GASES
(Period covered: March 1955–June 1956)
Allis, W. P., et al.
California, University of, Los Alamos Scientific Laboratory, New Mexico
LA-2055, W-7405-Eng-36, October 24, 1956

Lectures given at Los Alamos in the summer of 1955 concerning ionized gases (or plasma physics) are presented. They range from general principles of the statistical mechanics and the Boltzmann Transport Theory through Boltzmann and Fokker-Planck equations and their applications to ionized gases, to general and specific considerations of waves in plasma. A number of miscellaneous papers are included.

867. SOME ASPECTS OF THE HIGH FREQUENCY GAS DISCHARGE
Oskam, H. J.
***Nederlands Tijdschrift voor Natuurkunde*, v. 23, no. 1, pp. 1–15, January 1957 (in Dutch)**

A review paper of the theory and experimental measurements of the behavior of gas plasma in high-frequency fields. (*PA*, 1959, #8251)

868. SOME PROBLEMS IN HYDROMAGNETICS
Chopra, K. P.
University of Southern California, Engineering College, Los Angeles
USCEC 52-205, January 31, 1959 (210 pp.)
AFOSR TN 59-265
(ASTIA AD-212,468)

879. RESEARCH STUDY OF PLASMA ACCELERATION
Fonda-Bonardi, G.
Litton Industries of California, Beverly Hills
Final Report, V.P., September 30, 1959
AFOSR TR 59-170, AF 49(638)345

880. A REVIEW OF THE LITERATURE OF PLASMA PHYSICS
Covert, E. E. and Kerney, K.
Massachusetts Institute of Technology, Naval Supersonic Laboratory, Cambridge
TR 373, July 1959
WADC TR-59-486, AF 33(616)-5693, DSR 7931

The report discusses the level of development of plasma physics. It is found that the present theories account for the experimental effects if: (1) the plasma is sufficiently dense that the time between collisions is small compared to the time an atom stays in the excited state but is sufficiently rare that the volume of the particles making up the plasma is very much smaller than the volume of plasma, (2) the potential energy between particles is the sum of the particles potential energy, (3) the excitations are sufficiently weak, or the duration of the event is sufficiently short, that linearized theories are applicable. The literature search, approximately 50 pages of itemized references includes the following topics: "Absorption of Energy in a Plasma"; "Excitation of Plasma Oscillations by Electron Beams"; "Interaction of Microwaves and Plasma"; "Instrumentation of Plasma Experiments"; "Production of Plasma"; "Plasma Oscillations." Descriptive: "Properties of Ionized Gases"; "The Stellarator"; "Observations of Plasma Temperature, Energy, and Noise"; "Effect of H and E Fields and Transport Properties of Liquids and Gases at Room Temperatures"; "Cosmic and Terrestrial Applications of Magnetohydrodynamics"; "Magnetohydrodynamic Effects of Turbulence"; "Magnetohydrodynamic Waves"; "Magnetohydrodynamic Flows"; "Magnetohydrodynamic Oscillations"; "Cosmic Ray Production by Magnetohydrodynamics"; "Hall Effect Applied to Magnetohydrodynamics"; "Relativistic Magnetohydrodynamics."

881. ROCKET PROPULSION SYSTEMS FOR INTERPLANETARY FLIGHT
Sutton, G.
Journal of the Aero/Space Sciences, v. 26, no. 10, pp. 609–625, October 1959

882. AEROSCIENCES LABORATORY SUMMARY OF TECHNICAL REPORTS
General Electric Co., Missile and Space Vehicle Dept., Philadelphia, Pa.
AF 04(647)-269, January–June, 1959

This is a collection of selected research papers. Volume I is concerned with gas dynamics and Volume II with space mechanics, plasma physics, arc research, and life support. Pages of recent references on this subject are included.

883. BIBLIOGRAPHY OF PLASMA PHYSICS AND RELATED SUBJECTS
Stollenwerk, M.
Arnold Engineering Development Center, Tullahoma, Tenn.
TM-59-5, AF 40(600)-700, February 1959
(ASTIA AD-211,155)

884. BIBLIOGRAPHY ON PLASMA PHYSICS AND MAGNETOHYDRODYNAMICS AND THEIR APPLICATIONS TO CONTROLLED THERMONUCLEAR REACTIONS
Ramer, J. D., et al.
October 1959
University of Maryland, College Park, Engineering and Physical Sciences Library

885. FLUID DYNAMICS
Oppenheim, A. K.
Industrial Engineering Chemistry, v. 51, no. 3 (11), pp. 437–452, March 1959

Review of recent literature (books, periodical articles, conference proceedings and reports) on the following: equations of motion and stability; turbulence; vortex flow and rotation; jets and wakes; flow near solid surfaces; multiphase and free-boundary flow; gas dynamics; wave dynamics; dynamics of reactive fluids; dynamics of conducting fluids. The bibliography (arranged under the foregoing headings) contains 329 references. (*PA*, 1959, #5397)

886. ION ROCKET STUDY PROGRAM
Boden, R. H.
Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif.
QPR R-565-2P, August 14, 1957

The progress accomplished during the second quarter of contract AF 49(638)-16 is reported. Emphasis has been on the analysis of the components of the ion rocket engine system which are thought to present the major problems. The components studies include the ion thrust chamber, electron thrust chamber, propellants, heat sources, heat dissipators, and electrical power generators. Definition of specific experimental problems has been started. A literature search is included.

887. MAGNETOHYDRODYNAMICS EQUATIONS, PARAMETERS AND BIBLIOGRAPHY
Banks, R. B.
February 23, 1959
Northwestern University, Evanston, Ill.

888. LIST OF SCIENTIFIC REPORTS ON PLASMA PHYSICS, MAGNETOHYDRODYNAMICS AND THERMONUCLEAR REACTIONS IN THE CERN LIBRARY
European Organization for Nuclear Research, Geneva, Switzerland
Cern-Bib-1., December 1–8, 1958 (12 pp.)

A list is given of the approximately 170 AEC and UKAEA reports on plasma, magnetohydrodynamics, and thermonuclear reactions found in the Cern Library, Geneva. (*NSA*, 1959, #3683)

BOOKS

889. MAGNETOHYDRODYNAMICS

Landshoff, R. K. M.
Stanford University Press, Palo Alto, Calif.
1957, (115 pp.)

This compilation of the papers presented at the Magnetohydrodynamics Symposium held on December 29, 1956 is divided into two sections, namely "Theoretical Work" and "Laboratory Experiments."

A. R. Kantrowitz and H. E. Petschek present an introductory discussion of magnetohydronamics. They classify the domains of gaseous magnetohydrodynamics and define the various terms pertinent to the field. W. M. Elsasser discusses the dimensional aspects and presents the fundamental equations. He discusses the creation of magnetic loops. F. Hoyle in his paper concerns himself with the properties of completely ionized gases with particular reference to the build-up of large magnetic fields inside stars. J. M. Burgers discusses the application of the fundamental equations to the case when a plane shock wave penetrates into a magnetic field. Mr. Rosenbluth considers the dynamics of a pinched gas. In the second section, R. K. M. Landshoff presents scaling laws which may be used in the design of experiments. Magnetically driven shock waves are discussed by A. C. Kolb, S. W. Kash and others. An experiment on liquid sodium instability is described, and W. A. Newcomb presents a treatment of the hydromagnetic waveguide proposed by R. F. Post.

This little volume concerning the many aspects of magnetohydrodynamics contains multifarious information. It should be invaluable to all persons working or interested in this field. (*AMR*, 1958, #2664)

890. PROBLEMS IN HYDROMAGNETICS

Frieman, E. A. and Kulsrud, R. M.
"Advances in Applied Mechanics,"
(Edited by Dryden, H. L. and von Karman, T.),
New York Academic Press, v. 5, pp. 195–231, 1958

Authors give survey of selected topics of continuum hydromagnetics. Review is divided in three sections. The first and shortest treats motion of magnetic lines, an energy conservation theorem, and general question of hydromagnetic equilibrium. Second part, by far the best, is completely devoted to hydromagnetic stability. Authors derive criteria for stability by normal mode and energy methods. Few examples are given. In the third part hydromagnetic waves are discussed at length. Study is confined to infinitesimal amplitudes. Authors derive properties for reflection, refraction, and transmission of such waves. (*AMR*, 1959, #1036)

891. PLASMA DYNAMICS

Clauser, F. H.
Johns Hopkins University, Baltimore, Md., 1959

This volume is based on an international symposium on plasma dynamics held at Woods Hole in June 1958 under the sponsorship of the National Academy of Sciences–National Research Council and the Office of Scientific Research, Air Research and Development Command. Chapter titles are: "Experimental Research on High Temperature," Post, R. F.; "The Problems of Thermonuclear Fusion and High Temperature Plasmas," Rosenbluth, M.; "Gaseous Electronic Phenomena," Mittleman, M. H.; "Dynamics of Electron Beams," Gould, R. W.; "Statistical Plasma Mechanics," Burgers, J. M.; "Continuum Plasma Dynamics," Liepmann, H. S., Cole, J. D.; "Flight Magnetohydrodynamics," Kantrowitz, A.; "Solar, Planetary, and Interplanetary Magnetohydronamics," Parker, E. N.; and "Cosmical Magnetohydrodynamics," Burbidge, G.

892. ELECTROMAGNETIC PHENOMENA IN COSMICAL PHYSICS

Lehnert, B.
International Astronomical Union Symposium No. 6, held in Stockholm, August 1956
Cambridge University Press, England, 1958,
(554 pp.)

Theoretical and experimental papers were presented on fundamental magnetohydrodynamics including currents in gases in the presence of a magnetic field, stellar magnetism, and electromagnetic phenomena within the solar system. Solar-electrodynamics, magnetic storms and aurorae, and cosmic-ray intensity variations are included. (*NSA*, 1959, #10266)

893. SPACE TECHNOLOGY

Seifert, H., Editor (38 Authors)
John Wiley and Sons, Inc., New York, 1959

Chapter 18–"Magnetohydrodynamics." The Chapter is divided as follows: (1) Introduction, (2) Our Half-Volt World, (3) The Electrical Conductivity of Air, (4) Interaction of a Conducting Gas With a Magnetic Field, (5) The Basic Equations, (6) Some Fundamental Concepts, (7) Magnetic Control of the Boundary Layer, (8) Control of the Thermonuclear Reaction, (9) The Pinch Effect, (10) Application of Thermonuclear Reactions to Rocket Propulsion.

894. THE PLASMA IN A MAGNETIC FIELD. A SYMPOSIUM ON MAGNETOHYDRODYNAMICS

Landshoff, R. K. M., Editor
Stanford University Press, Palo Alto, Calif., 1958

The papers included in this second volume on magnetohydrodynamics deal with plasmas rather than with liquid metals. There are two papers on "Kinetic Theory," four on "Confinement and Instabilities of a Plasma," and four on "High-Speed Fluid Dynamics." Contributors include Chandrasekhar, Rosenbluth, Colgate, Karr, Weibel, Parker, Blackman, Kash, Scott, and Liepmann. The papers are by well-known experts in this field and are of considerable interest to the specialist.

895. PROCEEDINGS OF THE INTERNATIONAL CONGRESS OF RADIATION RESEARCH

Smith, D. E., Editor
Radiation Research Supplement No. 1, 1959, (582 pp.)

This volume is made up of the invited papers of several symposia of the International Congress of Radiation Research held in Burlington, Vermont on August 11–15, 1958. Abstracts of some of the papers will be published later. (*PA*, 1959, #5164)

896. COURSE ON TURBULENCE THEORY VOL. I

(Corse sulla Teoria della Turbolenza, Vol. Primo)
Kampe de Feriet, J., Ferrari, C., and Agostinelli, C.
Torino, Libreria Editrice Universitaria
Levrotto and Bella, 1957

This volume presents the text of a special course (or rather a symposium) on turbulence held in Varenna, Italy, during September 1957. (*AMR*, 1959, #2089)

897. THE MAGNETODYNAMICS OF CONDUCTING FLUIDS

Bershader, D., Editor
Stanford University Press, Palo Alto, Calif., September 1959

Seven authoritative analyses covering the underlying behavior of conducting fluids in magnetic fields are contained in this, the third volume to grow out of a Lockheed-sponsored symposium on magnetohydrodynamics. The contributors are Busemann, Carrier, Grad, Cole, Resler, Petschek, and Mitchner.

Electromagnetic theory and fluid mechanics are combined from the continuum point of view in order to discuss the physical concepts and obtain results relating to the influence of magnetic fields on wave propagation, shock tube flows, subsonic and supersonic nozzle flows, and viscous boundary layers. Though the studies are largely analytical, to them have been added some experimental results dealing with magnetohydrodynamic lift and with shock wave behavior. Particular attention is paid to new features which have no counterpart in ordinary fluid mechanics.

Mr. Bershader is Associate Professor of Aerodynamics at Stanford University and Manager of Gas Dynamics Research at Lockheed Missiles and Space Division.

898. ADVANCED PROPULSION SYSTEMS SYMPOSIUM, LOS ANGELES 1957

Alperin, M. and Sutton, G.
New York Symposium Publications Division, Pergamon Press, New York, 1959 (237 pp).

International series on aeronautical sciences and space flight. Division IX: Symposia, v. 2.

899. BASIC DATA OF PLASMA PHYSICS
Brown, S. C.
John Wiley and Sons, Inc., New York, 1959

900. CONFERENCE ON EXTREMELY HIGH TEMPERATURES
Fischer-Hjalmars, I. and Mansur, C., Editors
March 18–19, 1959
Sponsored by Electronics Research Directorate, Air Force Cambridge Research Center, Boston, Mass., March 18–19, 1959

The book contains the following papers: A-1. The Production of High Temperature Gas by Magnetic Acceleration, Janes, G. S., Patrick, R. M.; A-2. Upper Temperature Limits in the High Pressure Discharge, Fischer, H.; A-3. Combination of Electrically Exploded Wires and Electric Arc, Conn, W. M.; A-4 Analysis of the Direct Current Arc, Morris, A. D.; A-5. Inductive Energy Source—A Tool for High Temperature Research, Early, H. C., Walker, R. C.; A-6. Remarks on High Current Discharges at NRL, Kolk, A. C.; B-1. The Determination of the Equilibrium Temperature of a Plasma, Dickerman, P. J.; B-2. Recent Developments in Line Broadening Theory for High Temperature Gases, Griem, H.; B-3. A Microwave Thermometer for Millions of Degrees, Drummond, J. E.; B-4. Radiation Effects on Rankine-Hugoniot Shock Conditions, Guess, A. W., Sen, H. K.; B-5. Calculation of the Radical Distribution of Photon Emitters in Symmetric Sources, Pearce, W. J.; C-1. Plasma Diamagnetism as a Diagnostic Technique, Gordon, E. I.; C-2. Thermal Diffusion at High Temperatures in Ionized Gases, Chapman, S., Tandberg-Hanssen, E.; C-3. Stochastic Foundation of Generalized Macroscopic Equations of Change in a Reacting Plasma, Kaeppeler, H. J.; C-4. Plasma Motors, Bostick, W. H.; C-5. The Megatron, Finkelstein, D.; C-6. A Crossed Field Ionic Wind Motor, Early, H. C., Dow, W. G.; D-1. Plasma Acceleration Experiments, Korneff, T., Nadig, F. H., Bohn, J. L.; D-2. The Feasibility of Thermonuclear Propulsion, Clauser, M. U.; D-3. Plasma Generation Facility and Some Research Results, Ghai, M. L.; D-4. Behavior of Materials Subjected to Ultrahigh Temperature Environments, Bonin, J. H., Price, C. F.; D-5. High Magnetic Field Research, Levine, M. A., Sampson, J. L., Waniek, R. W.

901. ELECTROMAGNETIC RADIATION FROM CYLINDRICAL STRUCTURES
Wait, J. R.
Pergamon Press, New York, 1959
(*Battelle Technical Review*, December 1959)

902. HEAT TRANSFER AND FLUID MECHANICS INSTITUTE
Preprints of Papers, University of California, Berkeley, June 19–21, 1958
Stanford University Press, Palo Alto, Calif., 1958.

(Abstracted in *NSA*, 1959, #346)

903. MAGNETOHYDRODYNAMICS
Cowling, T. G.
Interscience Publishers, Inc. N. Y.
Interscience Tracts on Physics and Astronomy
1957–1958 (115 pp.)

Book treats a suggestive topic, viz., the action between the flow of gases or liquids and magnetic fields or electrical currents. Attractive applications are made by earlier authors on sunspots and their origin, the magnetic fields of the Sun, the Earth and of the interstellar space, and so on. Also technical applications are suggested, as for instance the generation of extremely high temperatures, but it has not been possible to bring all that within the frame of an interscience tract.

Book is an introduction to magnetohydrodynamics for readers who have some knowledge of fundamental differential equations of electromagnetics and hydrodynamics. It is a critical survey rather than a textbook.

Many a fancy proposition has appeared in the field of cosmic hydrodynamics with very remote possibilities of experimental check. It is true that some fundamental equations and their solutions have been checked through careful and sometimes dangerous experiments with mercury and liquid sodium. However, it has not been possible to simulate astrophysical conditions. This state of matters makes it the more valuable to receive the personal opinions and views regarding different hypotheses as laid down by an authority in this easily read little book.

The engineer still misses a comprehensive treatise on magnetohydrodynamics but he certainly will find inspiration in this book. (*AMR*, 1958, #3391)

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